Part II | Book 2

# FRM® EXAM PREP

# SCHWESER 2015

## SchweserNotes™ for the FRM® Exam

### Credit Risk Measurement and Management

KAPLAN UNIVERSITY SCHOOL OF PROFESSIONAL AND CONTINUING EDUCATION | SCHWESER

# FRM Part II Book 2: Credit Risk Measurement and Management

FRM 2015 PART II BOOK 2: CREDIT RISK MEASUREMENT AND MANAGEMENT



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# Reading Assignments and Learning Objectives

*The following material is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by the Global Association of Risk Professionals.*

## Reading Assignments

## Learning Objectives

**18. The Credit Decision**

After completing this reading, you should be able to:
1. Define credit risk and explain how it arises using examples. (page 13)
2. Explain the components of credit risk evaluation. (page 14)
3. Compare and contrast quantitative and qualitative techniques of credit risk evaluation. (page 16)
4. Compare the credit analysis of consumers, corporations, financial institutions, and sovereigns. (page 17)
5. Describe quantitative measurements and factors of credit risk, including probability of default, loss given default, exposure at default, expected loss, and time horizon. (page 19)
6. Compare bank failure and bank insolvency. (page 21)

**19. The Credit Analyst**

After completing this reading, you should be able to:
1. Describe, compare and contrast various credit analyst roles. (page 27)
2. Describe common tasks performed by a banking credit analyst. (page 32)
3. Describe the quantitative, qualitative, and research skills a banking credit analyst is expected to have. (page 33)
4. Assess the quality of various sources of information used by a credit analyst. (page 34)

**20. Default Risk: Quantitative Methodologies**

After completing this reading, you should be able to:
1. Describe the Merton model for corporate security pricing, including its assumptions, strengths and weaknesses:
    - Illustrate and interpret security-holder payoffs based on the Merton model.
    - Using the Merton model, calculate the value of a firm's debt and equity and the volatility of firm value.
    - Describe the results and practical implications of empirical studies that use the Merton model to value debt. (page 40)
2. Describe key qualities of credit scoring models. (page 45)
3. Compare the following quantitative methodologies for credit analysis and scoring: linear discriminant analysis, parametric discrimination, K nearest neighbor approach, and support vector machines. (page 45)
4. Differentiate between the following decision rules: minimum error, minimum risk, Neyman-Pearson and Minimax. (page 46)
5. Identify the problems and tradeoffs between classification and prediction models of performance. (page 47)
6. Describe important factors in the choice of a particular class of model. (page 47)

**21. Credit Risks and Credit Derivatives**

After completing this reading, you should be able to:
1. Explain the relationship between credit spreads, time to maturity, and interest rates. (page 57)
2. Explain the differences between valuing senior and subordinated debt using a contingent claim approach. (page 59)

3. Explain, from a contingent claim perspective, the impact of stochastic interest rates on the valuation of risky bonds, equity, and the risk of default. (page 59)
4. Assess the credit risks of derivatives. (page 68)
5. Describe a credit derivative, credit default swap, and total return swap. (page 68)
6. Explain how to account for credit risk exposure in valuing a swap. (page 71)

**22. Credit and Counterparty Risk**

After completing this reading, you should be able to:

1. Describe the credit risks associated with different types of securities. (page 77)
2. Differentiate between book and market values in a firm's capital structure. (page 78)
3. Describe common frictions that arise with the use of credit contracts. (page 79)
4. Explain the following concepts related to default and recovery: default events, probability of default, credit exposure, and loss given default. (page 80)
5. Calculate expected loss from recovery rates, the loss given default, and the probability of default. (page 82)
6. Differentiate between a credit risk event and a market risk event for marketable securities. (page 83)
7. Summarize credit assessment techniques such as credit ratings and rating migrations, internal ratings, and risk models. (page 83)
8. Describe counterparty risk, compare counterparty risk to credit risk, and explain how counterparty risk can be mitigated. (page 84)
9. Describe the Merton Model, and use it to calculate the value of a firm, the values of a firm's debt and equity, and default probabilities. (page 86)
10. Explain the drawbacks of and assess possible improvements to the Merton Model. (page 89)
11. Describe credit factor models and evaluate an example of a single-factor model. (page 90)
12. Define and calculate Credit VaR. (page 91)

**23. Spread Risk and Default Intensity Models**

After completing this reading, you should be able to:

1. Compare the different ways of representing credit spreads. (page 97)
2. Compute one credit spread given others when possible. (page 97)
3. Define and compute the Spread '01. (page 98)
4. Explain how default risk for a single company can be modeled as a Bernoulli trial. (page 99)
5. Explain the relationship between exponential and Poisson distributions. (page 100)
6. Define the hazard rate and use it to define probability functions for default time and conditional default probabilities. (page 100)
7. Calculate risk-neutral default rates from spreads. (page 102)
8. Describe advantages of using the CDS market to estimate hazard rates. (page 103)
9. Explain how a CDS spread can be used to derive a hazard rate curve. (page 104)
10. Explain how the default distribution is affected by the sloping of the spread curve. (page 106)
11. Define spread risk and its measurement using the mark-to-market and spread volatility. (page 107)

**24. Portfolio Credit Risk**

After completing this reading, you should be able to:
1. Define default correlation for credit portfolios. (page 113)
2. Identify drawbacks in using the correlation-based credit portfolio framework. (page 114)
3. Assess the impact of correlation on a credit portfolio and its Credit VaR. (page 115)
4. Describe the use of a single factor model to measure portfolio credit risk, including the impact of correlation. (page 117)
5. Describe how Credit VaR can be calculated using a simulation of joint defaults with a copula. (page 121)

**25. Structured Credit Risk**

After completing this reading, you should be able to:
1. Describe common types of structured products. (page 127)
2. Describe tranching and the distribution of credit losses in a securitization. (page 128)
3. Describe a waterfall structure in a securitization. (page 129)
4. Identify the key participants in the securitization process, and describe conflicts of interest that can arise in the process. (page 132)
5. Evaluate one or two iterations of interim cashflows in a three tiered securitization structure. (page 133)
6. Describe a simulation approach to calculating credit losses for different tranches in a securitization. (page 136)
7. Explain how the default probabilities and default correlations affect the credit risk in a securitization. (page 137)
8. Explain how default sensitivities for tranches are measured. (page 139)
9. Describe risk factors that impact structured products. (page 139)
10. Define implied correlation and describe how it can be measured. (page 140)
11. Identify the motivations for using structured credit products. (page 140)

**26. Defining Counterparty Credit Risk**

After completing this reading, you should be able to:
1. Describe counterparty risk and differentiate it from lending risk. (page 148)
2. Describe transactions that carry counterparty risk and explain how counterparty risk can arise in each transaction. (page 149)
3. Identify and describe institutions that take on significant counterparty risk. (page 150)
4. Describe credit exposure, credit migration, recovery, mark-to-market, replacement cost, default probability, loss given default and the recovery rate. (page 151)
5. Identify and describe the different ways institutions can manage and mitigate counterparty risk. (page 152)

**27. Netting, Compression, Resets, and Termination Features**

After completing this reading, you should be able to:
1. Explain the purpose of an ISDA master agreement. (page 157)
2. Summarize netting and close-out procedures (including multilateral netting), explain their advantages and disadvantages, and describe how they fit into the framework of the ISDA master agreement. (page 157)

3. Describe the effectiveness of netting in reducing credit exposure under various scenarios. (page 160)
4. Describe the mechanics of termination provisions and explain their advantages and disadvantages. (page 160)

**28. Collateral**

After completing this reading, you should be able to:
1. Describe features of a credit support annex (CSA) within the ISDA Master Agreement. (page 165)
2. Describe the role of a valuation agent. (page 166)
3. Describe types of collateral that are typically used. (page 166)
4. Explain the process for the reconciliation of collateral disputes. (page 167)
5. Explain the features of a collateralization agreement. (page 167)
6. Differentiate between a two-way and one-way CSA agreement and describe how collateral parameters can be linked to credit quality. (page 169)
7. Explain how market risk, operational risk, and liquidity risk (including funding liquidity risk) can arise through collateralization. (page 170)

**29. Credit Exposure**

After completing this reading, you should be able to:
1. Describe and calculate the following metrics for credit exposure: expected mark-to-market, expected exposure, potential future exposure, expected positive exposure and negative exposure, effective exposure, and maximum exposure. (page 176)
2. Compare the characterization of credit exposure to VaR methods and describe additional considerations used in the determination of credit exposure. (page 179)
3. Identify factors that affect the calculation of the credit exposure profile and summarize the impact of collateral on exposure. (page 179)
4. Identify typical credit exposure profiles for various derivative contracts and combination profiles. (page 180)
5. Explain how payment frequencies and exercise dates affect the exposure profile of various securities. (page 183)
6. Explain the impact of netting on exposure, the benefit of correlation, and calculate the netting factor. (page 184)
7. Explain the impact of collateralization on exposure, and assess the risk associated with the remargining period. (page 185)
8. Explain the difference between risk-neutral and real-world parameters, and describe their use in assessing risk. (page 188)

**30. Default Probability, Credit Spreads, and Credit Derivatives**

After completing this reading, you should be able to:
1. Distinguish between cumulative and marginal default probabilities. (page 195)
2. Calculate risk-neutral default probabilities, and compare the use of risk-neutral and real-world default probabilities in pricing derivative contracts. (page 196)
3. Compare the various approaches for estimating price: historical data approach, equity based approach, and risk neutral approach. (page 197)
4. Describe how recovery rates may be estimated. (page 199)
5. Describe credit default swaps (CDS) and their general underlying mechanics. (page 200)
6. Describe the credit spread curve and explain the motivation for curve mapping. (page 201)

7. Describe types of portfolio credit derivatives. (page 201)
8. Describe index tranches, super senior risk, and collateralized debt obligations (CDOs). (page 202)

**31. Credit Value Adjustment**

After completing this reading, you should be able to:

1. Explain the motivation for and the challenges of pricing counterparty risk. (page 209)
2. Describe credit value adjustment (CVA). (page 209)
3. Calculate CVA and the CVA spread with no wrong-way risk, netting, or collateralization. (page 209)
4. Evaluate the impact of changes in the credit spread and recovery rate assumptions on CVA. (page 211)
5. Explain how netting can be incorporated into the CVA calculation. (page 212)
6. Define and calculate incremental CVA and marginal CVA, and explain how to convert CVA into a running spread. (page 212)
7. Explain the impact of incorporating collateralization into the CVA calculation. (page 212)

**32. Wrong-Way Risk**

After completing this reading, you should be able to:

1. Describe wrong-way risk and contrast it with right-way risk. (page 218)
2. Identify examples of wrong-way risk and examples of right-way risk. (page 219)

**33. Credit Derivatives and Credit-Linked Notes**

After completing this reading, you should be able to:

1. Describe the mechanics and attributes of a single named credit default swap (CDS). (page 228)
2. Describe the mechanics and attributes of portfolio CDS. (page 230)
3. Describe the composition and use of CDS indices. (page 232)
4. Describe the mechanics and attributes of asset default swaps, equity default swaps, total return swaps and credit linked notes. (page 233)

**34. The Structuring Process**

After completing this reading, you should be able to:

1. Describe the objectives of structured finance and explain the motivations for asset securitization. (page 240)
2. Describe the process and benefits of ring-fencing assets. (page 241)
3. Describe the role of structured finance in venture capital formation, risk transfer, agency cost reduction, and satisfaction of specific investor demands. (page 242)
4. Explain the steps involved and the various participants in the structuring process. (page 243)
5. Describe the role of loss distributions and credit ratings in the structuring process. (page 244)

**35. Securitization**

After completing this reading, you should be able to:

1. Define securitization, describe the securitization process and explain the role of participants in the process. (page 249)
2. Analyze the differences in the mechanics of issuing securitized products using a trust versus a special purpose entity. (page 250)

3. Describe and assess the various types of internal and external credit enhancements. (page 251)
4. Explain the impact of liquidity, interest rate and currency risk on a securitized structure, and identify securities that hedge these exposures. (page 253)
5. Describe the securitization process for mortgage backed securities and asset backed commercial paper. (page 255)

**36. Cash Collateralized Debt Obligations**

After completing this reading, you should be able to:

1. Describe collateralized debt obligations (CDOs) and explain the motivations of CDO buyers and sellers. (page 259)
2. Describe the types of collateral used in CDOs. (page 259)
3. Explain the structure and benefits of balance sheet CDOs and arbitrage CDOs, and the motivations for using them. (page 261)
4. Compare cash flow and market value CDOs. (page 262)
5. Compare static and managed portfolios of CDOs. (page 263)

**37. Understanding the Securitization of Subprime Mortgage Credit**

After completing this reading, you should be able to:

1. Explain the subprime mortgage credit securitization process in the United States. (page 272)
2. Identify and describe key frictions in subprime mortgage securitization, and assess the relative contribution of each factor to the subprime mortgage problems. (page 272)
3. Describe the characteristics of the subprime mortgage market, including the creditworthiness of the typical borrower and the features and performance of a subprime loan. (page 275)
4. Describe the credit ratings process with respect to subprime mortgage backed securities. (page 276)
5. Explain the implications of credit ratings on the emergence of subprime related mortgage backed securities. (page 276)
6. Describe the relationship between the credit ratings cycle and the housing cycle. (page 276)
7. Explain the implications of the subprime mortgage meltdown on portfolio management. (page 277)
8. Compare predatory lending and borrowing. (page 277)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# The Credit Decision

Topic 18

## Exam Focus

This topic provides an overview of the credit analysis process. Credit risk can arise from multiple sources, including default, an increased probability of default, failure to perform on a prepaid obligation, more severe losses than forecasted resulting from greater exposure than expected, or smaller recoveries than expected given a default. For the exam, be able to compare and contrast the credit analysis process for consumers (i.e., individuals), nonfinancial firms, financial firms, and to a lesser degree sovereigns. Also, be able to distinguish between the probability of default (PD), the loss given default (LGD), the exposure at default (EAD), and the overall expected loss (EL). Understand that it is simple to measure these factors after the fact but difficult to forecast losses in advance. Finally, understand that outside of times of stress or crisis, banks rarely fail. Credit analysts must determine where a financial institution falls on a continuum between perfectly creditworthy and bankrupt.

## Credit Risk

### LO 18.1: Define credit risk and explain how it arises using examples.

**Credit** is an agreement where one party receives something of value and agrees to pay for the good or service at a later date. The word "credit" is derived from the ancient Latin word *credere,* which means "to believe" or "to entrust." The creditor must have knowledge of the borrower's character and reputation as well as his financial condition. Generally, there is not a definitive yes or no answer to whether a borrower can and will pay back a loan. As such, the lender must address the question of likelihood. The lender must assess the likelihood that the borrower will pay back the loan in accordance with the terms of the agreement.

*Professor's Note: Borrower, obligor, counterparty, and issuer are all used to signify the party receiving credit. Lender, creditor, and obligee are primarily used to signify the party granting credit.*

**Credit risk** is the probability that a borrower will not pay back a loan in accordance with the terms of the credit agreement. The risk can result from:

- Default on a financial obligation.
- An increased probability of default on a financial obligation.
- A more severe loss than expected due to a greater than expected exposure at the time of a default.
- A more severe loss than expected due to a lower than expected recovery at the time of a default.
- Default on payment for goods or services already rendered (i.e., settlement risk).

Credit risk arises in many personal and business contexts. In fact, nearly all businesses, except small firms that confine their businesses to "cash and carry" transactions (i.e., a good or service is exchanged simultaneously for cash), incur credit risk. Specific contexts in which credit risks arise include:

- A person or company performs a service and sends a bill for payment of the rendered service. For example, a car dealership fixes a person's car and then bills the customer, giving the customer 30 days to pay the bill in full without incurring financing charges.
- A party pays in advance for goods or services and awaits receipt of the goods or services (i.e., the settlement of a transaction). For example, a university pays in advance for computer training for its staff and faculty and then receives the training over the course of the following year.
- A person or company has provided a product and is awaiting payment for the item. **Trade credit** is an example of this type of transaction. The firm selling the product offers "terms of credit," allowing the purchaser a reasonable period of time to pay the invoice. Big-ticket items are almost exclusively sold on credit. For example, a chemistry firm buys several powerful microscopes from a supplier and is allowed to pay the full balance in 30 days.

There are two types of risks associated with these transactions. There is **settlement risk**, the risk that the counterparty will never pay for the good or service, and a more fundamental **financial obligation** that arises from the loan agreement. Credit risk that arises from trade credit is nearly indistinguishable from the credit risk that banks incur. Financial analysis must be performed in both cases to increase the likelihood that the borrower will fulfill the financial obligation. Banks cannot avoid credit risk; it is central to their business. There is no "cash and carry" model in banking. Banks accept money from depositors and other sources and lend the money to individuals and firms. Because banks cannot avoid credit risk, they must manage the risk through credit analysis and the use of risk mitigants such as collateral and loan guarantees.

## Credit Risk Evaluation Components

### LO 18.2: Explain the components of credit risk evaluation.

The four primary components of credit risk evaluation are as follows.

1. **The borrower's (or obligor's) capacity and willingness to repay the loan.** Questions the lender must consider include:
   - What is the financial capacity to pay?
   - Is it likely the borrower can fulfill its financial obligations through the maturity of the loan?
   - Are there outside forces that affect the borrower's capacity and/or willingness to pay? For example, does the ownership structure of the firm, relationships within and outside the firm, and other obligations of the firm affect the borrower's ability to pay?
   - How does the business itself affect the borrower's capacity to pay? Are there credit risk characteristics tied to this particular industry or sector? Does the firm have a niche within the industry or sector?

2. **The external environment and its effect on the borrower's capacity and willingness to repay the borrowed funds.** Factors such as the business climate, country risk, and operating conditions are relevant to the lender. Are there cyclical changes that will affect the level of credit risk? Will political risks affect the likelihood of repayment?

3. **The characteristics of the credit instrument.** The credit instrument might be a bond issue, a bank loan, a loan from a finance company, trade credit, or other type of debt agreement/security. Concerns include:
   - Risk characteristics that are inherent in the credit instrument, including legal risks and obligations that are specific to the instrument.
   - The maturity (also called "tenor") of the instrument.
   - Is the debt secured or unsecured? Is there collateral backing the loan? Are there loan guarantors?
   - Is the debt subordinated or senior to other obligations? What is the priority assigned to the creditor?
   - How do loan/bond covenants increase or decrease the credit risk for each party? Can the borrower repay the loan early without penalty? Can the lender call the loan? Can the security be converted to another form (e.g., a convertible bond)?
   - What is the denominated currency of the obligation?
   - Are there any contingent risks?

4. **The quality and adequacy of risk mitigants such as collateral, credit enhancements, and loan guarantees.** Secured lending (i.e., using risk mitigants in the lending process) is generally the preferred method of lending. If there is collateral, a bank or other lender may not have to force a delinquent borrower into bankruptcy but may instead sell the collateral to satisfy the financial obligation. Secured lenders are also generally in a better position than unsecured lenders in the event of bankruptcy. The use of collateral not only mitigates losses in the event of default, but also lowers the probability of default because the obligee typically does not want to lose the collateral. Historically, banks have substituted collateral for analysis of the borrower's ability to pay. In some sense, the use of collateral eliminates the need for credit analysis, or at the very least makes the credit decision simpler. A lender can normally put a market value on collateral and determine if it is sufficient to cover potential losses. Three issues regarding risk mitigants include:
   - Is the collateral pledged to, or likely to be pledged to, another loan?
   - Has there been an estimation of the value of the collateral?
   - If there is a loan guarantor, has there been sufficient credit analysis of the third party's willingness and ability to pay in the event the borrower does not pay? A guarantor accepts liability for debt if the primary borrower defaults. The bank is able to substitute analysis of the guarantor's creditworthiness for that of the primary borrower. Typically, the guarantor has a greater ability to pay than the primary borrower (e.g., a parent guaranteeing a child's car loan or a parent company guaranteeing a loan to a subsidiary).

## Qualitative and Quantitative Techniques

### LO 18.3: Compare and contrast quantitative and qualitative techniques of credit risk evaluation.

The willingness to repay a loan is a subjective attribute. Lenders must make unverifiable judgments about the borrower. In some cases, intuition, or "gut feelings," are necessary to conclude whether a borrower is willing to repay a loan. As such, **qualitative credit analysis techniques** are largely used to evaluate the borrower's willingness to repay. Qualitative techniques include:

- **Gather information** from a variety of sources about the character and reputation of the potential borrower. Old-fashioned lending relied on first-hand knowledge of the people and businesses in a town. In this case, lenders knew (or thought they knew) potential borrowers. It is more difficult in the modern world, where lending decisions are centralized, to know customers personally.
- **Face-to-face meetings** with the potential borrower to assess the borrower's character are routine in evaluating willingness to pay.
- **"Name lending"** involves lending to an individual based on the perceived status of the individual in the business community. Some lenders substitute name lending for financial analysis.
- **Extrapolating past performance into the future.** Lenders often assume that a pattern of borrowing and repaying in the past (e.g., a credit record compiled from past history with the borrower and data garnered from credit bureaus) will continue in the future.

Historical lending norms relied on the *moral obligation* of borrowers who could pay to repay their debts. Thus, gauging the borrower's willingness to pay was a critical component of credit analysis. However, in modern society, the moral obligation to pay if one is capable of paying has been replaced by the legal obligation to pay. In other words, in terms of credit analysis, determining the capacity to pay is more important than determining the willingness to pay because the legal system will force those who can pay to honor their commitment. Courts can seize the assets of those who will not fulfill their financial obligations. In corrupt or ineffective states, a borrower will not suffer, even if able to pay but not doing so.

The willingness to pay is more important in countries with less-developed financial markets and legal systems. Creditors must evaluate the legal system and the strength of creditors' rights in emerging markets, along with the prospective borrower's ability and willingness to repay the obligation. This is a qualitative endeavor. **Sovereign risk ratings** may be used to evaluate the quality of a country's legal system and, by extension, the legal risk associated with the country or region. The lower the score, the greater the legal risk. For example, in 2010, Finland had a Rule of Law Index of 1.97, the United States had a rating of 1.58, Brazil had a rating of 0.0, and Somalia had a rating of –2.43. However, even in countries with robust legal systems such as Finland and the United States, the creditor must also consider the costs associated with taking legal action against a delinquent borrower. If costs are high, the creditor may be unwilling to take action regardless of the strength of the enforcement of creditor rights. As such, the willingness to pay should never be completely ignored in credit analysis.

The ability of a borrower to repay a loan is an objective attribute. **Quantitative credit analysis techniques** are largely used to evaluate the borrower's ability to repay. The primary quantitative technique used in financial analysis is examining the past, current, and forecasted financial statements of the prospective borrower. This forms the core of the quantitative credit analysis used to determine a borrower's capacity to meet its financial obligations. There are limitations associated with quantitative data, which include:

- **Historical nature of the data.** Financial data is typically historical and thus may not be up-to-date or representative of the future. Also, forecasted financial data is notoriously unreliable and susceptible to miscalculations and/or misrepresentations.
- **Difficult to make accurate projections using historical data.** Financial statements attempt to represent the economic reality of a firm in a highly abbreviated report. As such, some information is lost in translation that is critical to the loan decision. The rules guiding financial reporting are created by a diverse group with varying interests and are often decided by compromise. Also, firms are given discretion regarding what and how they report financial information, subject to established accounting rules. Firms may use the latitude in financial reporting to deceive interested parties. Even if the reports are accurate, financial data is subject to interpretation. There can be a range of conclusions drawn from the same data due to the variety of needs, perspectives, and experiences of the various analysts. This means there is a subjective, qualitative component to an objective, quantitative exercise.

Given the shortcomings of financial reporting, lenders should not ignore qualitative analysis. The quality of management, the motivation of the firm's management, and the incentives of management are relevant for both nonfinancial and financial firms. Even quantitative analysis is subject to interpretation. In fact, many would argue that financial analysis is much more of an art than a science. Judgment is as important as the quantitative analysis supporting it. The most effective analysis combines quantitative assessments with qualitative judgments.

## Credit Analysis Comparison

### LO 18.4: Compare the credit analysis of consumers, corporations, financial institutions, and sovereigns.

Four basic types of borrowers for which credit analysis must be performed are as follows:

1. **Consumers**—the analyst evaluates the creditworthiness of individuals.

2. **Corporations**—the analyst evaluates the creditworthiness of nonfinancial firms. Businesses are typically more difficult to analyze than individuals, although the process is similar.

3. **Financial institutions**—the analyst evaluates the creditworthiness of financial institutions, including banks and nonbank firms such as insurance companies and investment companies.

4. **Government or government-related entities (i.e., sovereigns)**—the analyst evaluates the creditworthiness of nations, government bodies, and municipalities. Non-state entities in specific locations or jurisdictions are also subject to analysis in the sovereign category.

There are similarities and differences in the approaches taken to analyze the creditworthiness of the various groups. Figure 1 details some specific aspects of each type of analysis.

**Figure 1: Comparison of Borrowers**

| | *Consumers* | *Corporations* | *Financial Institutions* | *Sovereigns* |
|---|---|---|---|---|
| *Capacity* | Wealth (i.e., net worth), salary, or incoming cash per period, expenses per period, assets such as houses and cars, amount of debt (e.g., credit card debt), net cash available to service debt (i.e., cash flow minus household and mortgage expenses). | Liquidity, cash flow combined with earnings capacity and profitability, capital position (solvency), state of the economy, strength of the industry. | Similar to nonfinancial firms but bank specific. Liquidity (the bank's access to cash to meet obligations), capital position, historical performance including earnings capacity over time (and ability to withstand financial stress), asset quality (affects the bank's likelihood of being paid back and by extension the bank's lender's likelihood of being paid back), state of the economy, strength of the industry. | Financial factors including the country's external debt load and debt relative to the overall economy; tax receipts are important. |
| *Willingness* | Reputation of individual, payment history. | Quality of management, historical debt service. | Quality of management; qualitative analysis is even more important for financial firms than for nonfinancial firms. | Credit analysis for sovereigns is often more subjective than for financial and nonfinancial firms because the legal system and the enforcement of creditor rights is critical to the analysis. Sovereign legal risk ratings, as discussed previously, are often considered in the analysis. |

**Figure 1: Comparison of Borrowers (Cont.)**

| | *Consumers* | *Corporations* | *Financial Institutions* | *Sovereigns* |
|---|---|---|---|---|
| *Methods of evaluation* | Credit scoring models that consider income, duration of employment, and amount of debt for unsecured debt like credit cards. Credit scoring and some manual input and review for large exposures such as mortgage loans or automobile loans. | Detailed manual analysis including financial statement analysis, interviews with management. More complex than consumer analysis because companies are so diverse in terms of assets, cash flow, financial structure, etc. | Similar to nonfinancial firms. | Similar to financial and nonfinancial firms but with increased subjective analysis of the political environment. |
| *Loan size/type* | Large exposures are typically secured (e.g., mortgage loans). Smaller exposures are unsecured (e.g., credit card loans). | Typically larger exposures (sometimes considerably larger) than loans to consumers. Debt may be secured or unsecured. | Similar to nonfinancial firms (i.e., large). | Similar to nonfinancial and financial firms (i.e., large). |

The two primary differences between nonfinancial firm credit analysis and financial firm credit analysis are (1) the importance of the quality of assets in financial firms and (2) cash flow as an indicator of capacity to repay for nonfinancial firms but not a key indicator of creditworthiness for financial firms. It is clear from the 2007–2008 financial crisis that asset quality is a key indicator of a bank's financial health. The ability to withstand financial stress is critical for a bank. That is why earnings capacity over time is a more relevant indicator of creditworthiness than cash flow. A bank must be able to withstand periods of financial stress/crisis in order to repay debts.

*Professor's Note: Sovereign credit analysis is not explicitly discussed in this topic. However, in contrast to consumers and financial and nonfinancial firms, consider the political issues/concerns that would arise when lending to a foreign government. Even a financially healthy sovereign may be a risky loan candidate due to the legal system's strength (or lack thereof); a lack of legal protections for creditors and other factors might negatively affect the lender and the lender's rights. If you have to compare credit analysis across the four groups (i.e., consumers, nonfinancial firms, financial firms, and sovereigns), think about the differences between the groups and the various factors that explain and/or increase/decrease the lender's risk in each case.*

## Quantitative Measures

**LO 18.5: Describe quantitative measurements and factors of credit risk, including probability of default, loss given default, exposure at default, expected loss, and time horizon.**

Credit risk, the likelihood that a borrower will repay a loan according to the loan agreement, and default risk, the probability that a borrower will default, are essentially the

same because a default on a financial obligation almost always results in a loss to the lender. In the last decade, there have been significant changes in the financial sector. These changes, combined with regulatory changes in the industry, have resulted in a somewhat revised view of credit and default risks. Current measures used to evaluate creditworthiness are described as follows:

**Probability of default (PD):** The likelihood that a borrower will default is not necessarily the creditor's greatest concern. A borrower may briefly default and then quickly correct the situation by making a payment, paying interest charges or penalties for missed payments. Creditors must rely on other measures of risk in addition to PD.

**Loss given default (LGD):** LGD represents the likely percentage loss if the borrower defaults. The severity of a default is equally as important to the creditor as the likelihood that the default would occur in the first place. If the default is brief and the creditor suffers no loss as a result, it is less of a concern than if the default is permanent and the creditor suffers significant losses. Both PD and LGD are expressed as percentages.

**Exposure at default (EAD):** The loss exposure may be stated as a dollar amount (e.g., the loan balance outstanding). EAD can also be stated as a percentage of the nominal amount of the loan or the maximum amount available on a credit line.

**Expected loss (EL):** Expected loss for a given time horizon is calculated as the product of the PD, LGD, and EAD (i.e., PD × LGD × EAD).

**Time horizon:** The longer the time horizon (i.e., the longer the tenor of the loan), the greater the risk to the lender and the higher the probability of default. Also, EAD and LGD change with time. The exposure (EAD) increases as the borrower draws on a credit line and falls as the loan is paid down. The LGD can also change as the terms of the loan or credit line change.

Expected loss generally depends on four variables: PD, LGD, EAD, and time horizon. A bank should also consider the correlations between various risk exposures when analyzing credit risk in a portfolio context.

**Example: Calculating expected loss**

Star City Bank and Trust has examined its loan portfolio over the past year. It has determined that the probability of default was 4%, adjusted for the size of the exposure. The loss given default over the period was 80%. Bank risk managers estimate that the exposure at default was 75% of the potential exposure. **Calculate** the expected loss given a one-year time horizon.

**Answer:**

$$\text{expected loss} = 4\% \times 80\% \times 75\% = 2.4\%$$

*Professor's Note: It is straightforward to calculate PD, LGD, and EAD after the fact. As the previous example illustrates, a lender can analyze historical occurrences of default, loss given default, and loss exposure. However, it is difficult to estimate these measures in advance. A financial institution or other nonbank lender can use historical experience to help predict future losses, but the forecast will not be perfect. Using historical mortgage loss data would have been little help in forecasting actual losses that occurred during the 2007–2008 financial crisis.*

## Failure vs. Insolvency

### LO 18.6: Compare bank failure and bank insolvency.

Bank insolvency and bank failures are not identical. Banks become insolvent and are often merged into healthier institutions. It is more convenient and less expensive for the government to simply fold a troubled bank into a stronger bank than it is to close the bank. In fact, there is an assumption that bank failures are relatively common, but in reality, it rarely happens in non-crisis periods. Weak banks are merged with healthier banks, and the system avoids outright failures. This is especially true for large, international banks (i.e., banks that are "too big to fail"). In the United States, only 50 banks failed between 2001 and 2008, half of which failed in 2008. This equates to a rate of approximately 0.1% per year during the period. Following the financial crisis, approximately 2% of banks failed in both 2009 and 2010. An additional 1.2% of banks failed in 2011. Research indicates that bank failures are considerably less likely than nonfinancial firm failures.

In the last few years, beginning with the financial crisis in late 2007, many more large banks in Europe and the United States have suffered from financial stresses. However, it was clear during the crisis that some banks were considered too big to fail. In response, the Financial Stability Board (FSB) created a list of 29 "systemically important financial institutions" that are required to hold "additional loss absorption capacity tailored to the impact of their [possible] default." The concern is systemic risk that spreads to other institutions. There was substantial evidence of this occurrence during the financial crisis.

A bank can remain insolvent (without failing), so long as it has a source of liquidity. The Federal Reserve is one such source and acts as a "lender of last resort." A bank failure that results in significant losses to depositors and other creditors is quite rare, although as noted, the incidence increases in times of crisis, such as in 2008. For a credit analyst evaluating a financial institution, the expectation of an outright failure is unlikely. However, because banks are heavily leveraged, the risks cannot be ignored. The analyst must place the bank somewhere on the continuum between "pure creditworthiness" and bankrupt. At one end of the continuum are banks with AAA-rated debt, and at the other end are banks with default ratings. Thus, thinking about bank risk on a continuum is useful in defining the bank's credit risk.

## Key Concepts

### LO 18.1

Credit risk is the probability that a borrower will not pay back a loan in accordance with the terms of the credit agreement. Credit risk results when an individual or firm defaults on a financial obligation. It arises short of default when there is an increased probability of default on a financial obligation. A more severe loss than expected due to a greater than expected exposure at the time of a default or a more severe loss than expected due to a lower than expected recovery at the time of a default are also components of credit risk. Finally, credit risk can arise from a default on a payment for goods or services that are already rendered (i.e., settlement risk).

### LO 18.2

There are four primary components of credit risk evaluation: (1) the borrower's (obligor's) willingness and capacity to repay the loan, (2) the effect of external conditions on the borrower's ability to repay the loan, (3) the inherent characteristics of the credit instrument and the extent to which the characteristics affect the borrower's willingness and ability to perform the obligation, and (4) the quality and adequacy of risk mitigants such as collateral and loan guarantees.

### LO 18.3

Qualitative techniques are used primarily to assess the borrower's willingness to repay the loan. Quantitative techniques are used primarily to assess the borrower's ability to repay the loan. Gathering information from a variety of sources about the character and reputation of the potential borrower, face-to-face interviews with potential borrowers, and using past loan payment information to draw conclusions about a borrower's willingness to pay in the future are all qualitative techniques. Analyzing the borrower's recent and past financial statements is the primary quantitative method used in credit analysis.

### LO 18.4

There are key differences between the analysis of the creditworthiness of consumers, versus that of nonfinancial and financial firms. Individual factors such as a person's net worth, salary, assets, reputation, and credit score are used to evaluate individuals. It is more complex to evaluate firms. Liquidity, cash flow combined with earnings capacity and profitability, capital position (solvency), state of the economy, and strength of the industry are used to evaluate nonfinancial firms. Similar data is used for financial firms in addition to bank-specific measures such as capital adequacy, asset quality, and the bank's ability to withstand financial stress. Detailed manual analyses, including financial statement analysis and interviews with management, are used to analyze the creditworthiness of both nonfinancial and financial firms.

## LO 18.5

Current measures used to evaluate credit risk are:

- The probability of default (PD), which is the likelihood that a borrower will default.
- The loss given default (LGD), which represents the likely percentage loss if the borrower does default.
- Exposure at default (EAD), which can be stated as a dollar amount (e.g., the loan balance outstanding) or as a percentage of the nominal amount of the loan or the maximum amount available on a credit line.
- Expected loss (EL), which is, for a given time horizon, calculated as the product of the PD, LGD, and EAD (i.e., PD × LGD × EAD).
- Time horizon or tenor of the loan. The longer the time horizon, the greater the risk to the lender.

## LO 18.6

Bank insolvency and bank failure are not one in the same. A bank may be insolvent but avoid failure so long as liquidity is available. Also, many insolvent banks are merged with financially sound banks, avoiding outright failure. For the credit analyst, the fact that failure of financial institutions is rare makes analysis easier. However, banks are highly leveraged, placing the bank somewhere on the continuum between fully creditworthy and insolvent.

## Concept Checkers

1. Blackstone Credit, Inc., made a loan to a small start-up firm. The firm grew rapidly, and it appeared that Blackstone had made a good credit decision. However, the firm grew too fast and could not sustain the growth. It eventually failed. Blackstone had initially estimated its exposure at default to be $1,200,000. Because of the firm's rapid growth and resulting increases in the line of credit, Blackstone ultimately lost $1,550,000. In terms of credit risk, this is an example of:
   A. default on payment for goods or services already rendered.
   B. a more severe loss than expected due to a ratings downgrade by a rating agency.
   C. a more severe loss than expected due to a greater than expected exposure at the time of a default.
   D. a more severe loss than expected due to a lower than expected recovery at the time of a default.

2. Brent Gulick, a credit analyst with Home Town Bank, is considering the loan application of a small, local car dealership. The dealership has been solely owned by Bob Justice for more than 20 years and sells three brands of American automobiles. Because of the rural location, most of the cars sold in the past by the dealership have been large pick-up trucks and sports utility vehicles. However, sales have declined, and gasoline prices have continued to increase. As a result, Justice is considering selling a line of hybrid cars. Justice has borrowed from Home Town Bank before but currently does not have a balance outstanding with the bank. Which of the following statements is not one of the four components of credit analysis Gulick should be evaluating when performing the credit analysis for this potential loan?
   A. The business environment, competition, and economic climate in the region.
   B. Justice's character and past payment history with the bank.
   C. The car dealership's balance sheets and income statements for the last few years as well as Justice's personal financial situation.
   D. The financial health of Justice's friends and family who could be called upon to guarantee the loan.

3. Sarah Garrison is a newly hired loan officer at Lexington Bank and Trust. Her boss told her she needs to make five commercial loans this month to meet her sales goal. Garrison talks to friends and hears about a local businessperson with a great reputation. Everyone in town says John Johnson is someone you want to meet. Garrison sets up a meeting with Johnson and is immediately impressed with his business sense. They discuss a loan for a new venture Johnson is considering, and Garrison agrees that it is a great idea. She takes the loan application back to the bank and convinces the chair of the loan committee that Lexington Bank and Trust is lucky to be able to do business with someone with Johnson's reputation. This is an example of:
   A. historical analysis technique.
   B. qualitative analysis technique.
   C. quantitative analysis technique.
   D. extrapolation analysis technique.

4. Stacy Smith is trying to forecast the potential loss on a loan her firm made to a mid-size corporate borrower. She determines that there will be a 75% loss if the borrower does not perform the financial obligation. This is the:
A. probability of default.
B. loss given default.
C. expected loss.
D. exposure at default.

5. Bank of the Plain States has been struggling with poor asset quality for some time. The bank lends primarily to large farming operations that have struggled in recent years due to a glut of soybeans and corn on the market. Bank regulators have recently required that the bank write off some of these loans, which has entirely wiped out the capital of the bank. However, the bank still has some liquidity sources it can use, including a correspondent bank and the Federal Reserve. Bank of the Plain States is:
A. an insolvent but not failed bank.
B. both a failed bank and an insolvent bank.
C. neither a failed bank nor an insolvent bank.
D. a failed bank but not an insolvent bank.

## Concept Checker Answers

1. **C** Blackstone lost more than expected due to greater exposure at the time of default than initially estimated. The borrowing firm was a small start-up, so it was not likely rated. There were no goods or services rendered in this case. In addition, there is no mention of recovery. This is also an example of credit risk arising from default on a financial obligation.

2. **D** There are four primary components of credit risk evaluation: (1) the borrower's (obligor's) willingness and capacity to repay the loan, (2) the effect of external conditions on the borrower's ability to repay the loan, (3) the inherent characteristics of the credit instrument and the extent to which the characteristics affect the borrower's willingness and ability to repay the loan, and (4) the quality and adequacy of risk mitigants such as collateral and loan guarantees. In this case, the local business environment, Justice's character, his payment history, and the business's financial positions are all relevant. While risk mitigants such as collateral and loan guarantees are part of credit analysis, it is unlikely that a local car dealer who has been in business for 20 years would be seeking a loan guarantee from a friend or family member. In addition, even if Justice were looking at a potential loan guarantor, Gulick would not simply evaluate his "friends and family" but would evaluate the specific person or business that intended to guarantee the loan.

3. **B** Name lending is a qualitative technique that is sometimes used to take the place of financial analysis. It is a technique used to evaluate the borrower's willingness to repay a financial obligation.

4. **B** Current measures used to evaluate credit risk include the firm's probability of default, which is the likelihood that a borrower will default; the loss given default, which represents the likely percentage loss if the borrower does default; the exposure at default; and the expected loss, which is, for a given time horizon, calculated as the product of the PD, LGD, and EAD. The stated 75% loss if the borrower defaults is the loss given default or LGD.

5. **A** Bank of the Plain States is insolvent because capital is wiped out. However, the bank has not failed because it is still operating with liquidity from the correspondent bank and the Federal Reserve. Therefore, the bank is insolvent but not failed.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# The Credit Analyst

Topic 19

## Exam Focus

This topic focuses on the role and tasks performed by a banking credit analyst. For the exam, understand the objectives of the analyst (e.g., risk management, investment selection) as well as the difference between primary and secondary research. In addition, know the quantitative and qualitative skills that an analyst must possess in order to be successful. Finally, be able to recognize and describe the key information sources used by credit analysts such as the annual report, auditor's report, and company financial statements.

## Credit Analyst Roles

**LO 19.1: Describe, compare and contrast various credit analyst roles.**

There are several methods to describe, compare, and contrast the various credit analyst roles, including:

- Job descriptions (e.g., consumer credit analyst, credit modeling analyst, corporate credit analyst, counterparty credit analyst, credit analysts at rating agencies, sell-side/buy-side fixed-income analysts, bank examiners and supervisors).
- Functional objective (e.g., risk management vs. investment selection, primary vs. secondary research).
- Type of entity analyzed (e.g., consumer, corporate, financial institution, sovereign/ municipal).
- Classification by employer (e.g., banks and other financial institutions, institutional investors, rating agencies, government agencies).

### Job Description

Brief descriptions of typical analyst roles provide a general understanding and an appreciation for the wide range of available roles.

#### *Consumer Credit Analyst*

- An administrative role with little opportunity for detailed analysis, data entry duties for loans that are then scored electronically (i.e., the relative score will determine status as approved or declined).
- Primarily works with individual consumer mortgages, with a key objective that all documentation is in place for approved loans.
- Large dollar loans referred by analyst to more senior personnel.

### *Credit Modeling Analyst*

- A more quantitative role focused on the electronic scoring system described previously; some interaction with risk management personnel.
- Developing, testing, implementing, and updating various consumer credit scoring systems.

### *Corporate Credit Analyst*

- Scope of analysis is limited to corporations (i.e., no financial institutions or sovereign credits).
- Some duties developing credit risk models may be required.

### *Counterparty Credit Analyst*

- Analyzes typical counterparties (i.e., banks, nonbanks—brokers, insurance companies, hedge funds); usually employed by a financial institution to analyze other institutions with which it contemplates a two-way transaction.
- Performs credit reviews, approves limits, and develops/updates credit policies and procedures.
- Review process is often detailed requiring the following: (1) capital structure analysis (i.e., debt, equity), (2) financial statement analysis, (3) qualitative analysis of counterparty, and (4) qualitative analysis of the operating sector of counterparty.
- Finally, an internal rating is assigned and the analyst may also be required to comment on any of the following: (1) recommended limits to set on certain credit risk exposures, (2) approval or denial of a given credit application, and (3) recommended changes to the amounts, tenor, collateral, or other provisions of the transaction.

### *Credit Analysts at Rating Agencies*

- Provide unbiased external ratings on bonds and other debt instruments issued by financial institutions, corporations, and governments.

### *Sell-Side and Buy-Side Fixed-Income Analysts*

- Employed by financial institutions or hedge funds.
- In addition to credit risk, there is a focus on the relative value of debt instruments and their attractiveness as investments.

### *Bank Examiners and Supervisors*

- Assessing the financial stability of financial institutions within a supervisory (risk management) role.

## Functional Objective

Most credit analysts are employed to evaluate credit risk as part of an entity's overall risk management function. At the same time, others are employed for security selection and investment opportunity purposes. In terms of the amount and nature of work performed by analysts, there is a distinction between performing primary research versus secondary research.

### *Risk Management*

Credit risk management is the most common functional objective, and it occurs in both the private and public sector. Credit risk analysts in the public sector will perform research on potential counterparties. The output of the research typically consists of internal use credit reports on the counterparties as well as recommendations as to which deals to accept and the appropriate risk limits. Bank examiners operate in the public sector in a regulatory capacity by reviewing the credit risk of certain financial institutions. Within that role, two key risk management objectives for the financial system are to ensure it is robust and to promote depth and liquidity.

### *Investment Selection*

Investment selection is a much less common functional objective. Generally, credit analysts examine fixed-income securities with a focus on the risk of default. Specifically, an analyst must assess the likelihood of a given investment deteriorating in credit quality, thereby increasing credit risk and resulting in a decline in value. Additionally, a fixed-income analyst must also focus on the relative value of the investment. Relative value refers to the attractiveness of a given debt security compared to similar securities (e.g., other debt issues with the same asset class or same rating).

### *Rating Agency*

The work of rating agency analysts is used for both risk management and investment selection purposes. The analysts examine issuers, counterparties, and debt in generally the same manner as credit risk analysts in the public sector.

### *Primary Research*

Primary research refers to analyst-driven credit research or fundamental credit analysis. This is usually detailed (and often time-consuming) research with human effort that is both quantitative and qualitative in nature. The analysis looks at microeconomic factors (specific to the entity) and macroeconomic factors (e.g., political, industry). Rating agency analysts provide value by performing detailed credit analysis and arriving at independent conclusions, all of which is subsequently relied upon by other analysts. One of the disadvantages of primary research is its high cost; as a result, some financial institutions have an automated credit scoring system for simpler and less expensive transactions.

### *Secondary Research*

It is often difficult for the credit analyst to perform detailed first-hand analysis (e.g., in-person visits), especially if the counterparty is very large or is located in a foreign country. An alternative is to perform secondary research, which involves researching the ratings provided by other rating agency analysts. Such information is combined with other relevant information sources, current information about the counterparty, and the analyst's own research, to conclude the counterparty's credit risk assessment. Given the reliance on other research, secondary research reports tend to be much shorter than primary research reports.

The goal of using secondary research is for a financial institution to perform counterparty credit analysis in a quick and efficient manner while maintaining reliability.

## Type of Entity Analyzed

### *Corporate Credit Analyst*

This role focuses on analyzing firms that are not financial institutions, notable examples being manufacturing firms or service providers. The purpose of the analysis is to assess the level of the firm's credit risk. That assessment is then used in deciding whether or not an entity would conduct business with, lend money to, or purchase securities of the other firm. In general, such analysis is very specialized based on the industry as well as focused on specific transactions.

Although the basic analytical principles are the same, there is huge diversity in the sectors, products, size, and geographic locations of the firms being analyzed. As a result, the corporate credit analyst must possess specific industry knowledge in order to be effective. An analyst will generally focus on only one or two industries, especially among fixed-income and rating agency analysts (given their need to perform detailed primary research).

Common sectors analyzed include the following: (1) real estate, (2) chemicals, (3) energy, (4) utilities, (5) telecommunications, (6) natural resources, (7) paper and forest products, and (8) automotive.

Another point of consideration is the size of the firm being analyzed. With a large public company, there may be a lot of public information available that would only necessitate secondary research, thereby reducing costs. With a smaller private company, less information is likely available, and as a result, more due diligence and primary research would be required, thereby increasing costs.

Finally, cash flow analysis is key to assessing corporate credit risk, so corporate analysts must also be equipped with strong accounting and financial statement analysis skills.

### *Bank and Financial Institution Credit Analyst*

Counterparty credit analysts are employed by banks and other financial institutions and focus on analyzing the creditworthiness of other banks and other financial institutions. Compared to corporate credit analysis, the objective is not to make a lending decision but to determine whether the entity being analyzed is sufficiently creditworthy to function as a counterparty in future two-way transactions, with the entity requesting the analysis. Counterparty analysts could also establish exposure limits or decide whether to transact with the potential counterparty.

Both the nature of the financial instrument(s) and the length of time (tenor) of proposed contracts have a direct impact on the potential losses, and, as a result, have a direct impact on the type of analysis to be performed. Common financial instruments involved in counterparty transactions include (1) unsecured debt through the interbank market, (2) repurchase (repo) or reverse repurchase (reverse repo) transactions, (3) receivables factoring, (4) foreign exchange, and (5) derivatives.

### *Sovereign/Municipal Credit Analyst*

Sovereign credit analysts determine the risk of default by foreign governments on borrowed funds. Primarily, sovereign credit analysts need to consider macroeconomic indicators in determining a government's ability to repay its debts. Additionally, political risk is an important consideration; the analyst attempts to gauge political stability and its impact on the ability to repay. Sovereign credit analysts examine the risks involved with specific international transactions or transactions with specific countries, provinces, states, or cities.

The stability of a given country's banking system strongly correlates with the ability of a country's government to repay foreign debt. The correlation also means that a government's financial stability impacts its banking system. Therefore, when analyzing the credit risk of foreign banks, analysts must place a lot of emphasis on sovereign risk. The obvious component of sovereign risk would include an analysis of the foreign country's debt-issuing ability in addition to the securities already issued. Another component would include an analysis of the impact of the country's general operating environment on its banking environment.

## Classification by Employer

### *Banks, Nonbank Financial Institutions, and Institutional Investors*

Credit analysts are most frequently employed by banks. Amongst all three groups, credit analysts usually function either within a risk management or an investment selection role.

### *Rating Agencies*

Credit analysts employed by rating agencies analyze banks, corporations, and governments to determine their creditworthiness. Analysis includes the following steps:

*Step 1:* A general analysis of the credit risk of the entity.
*Step 2:* An analysis of issued securities and their impact on credit risk.
*Step 3:* An overall rating recommendation for the entity (communicated through rating symbols that are widely recognized and understood).

The information provided by the rating agencies is used by investors and risk personnel in making decisions regarding lending amounts, lending rates, and investment amounts.

### *Government Agencies*

A typical role is a regulatory one, whereby the credit analyst analyzes a bank or insurance company to determine its level of risk, financial stability, and whether it meets the regulatory requirements to continue operating. A lesser-known role is when the government acts as an investor or lender, whereby the credit analyst has similar functions (i.e., investment selection or a risk management focus) to its counterparts in other organizations.

### *Rating Advisor*

This is a unique role most frequently found in investment banks. The rating advisor has likely been a rating agency analyst and is now working to help a debt issuer obtain the highest rating possible. The rating advisor would perform an independent credit analysis of the issuer to arrive at a likely rating. The advisor would then provide advice to the issuer on how to mitigate any issues and respond to rating agency questions.

## Banking Credit Analyst Tasks

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**LO 19.2: Describe common tasks performed by a banking credit analyst.**

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There are three main types of banking credit analysts: (1) counterparty credit analyst, (2) fixed-income analyst, and (3) equity analyst. Common tasks for each type of analyst are described in the following.

**Counterparty credit analysts** perform risk evaluations (reports) for a given entity. The triggering event to perform such evaluations may be an annual review of the entity or an intent to engage in an upcoming transaction with that entity. The tasks might be limited to simply covering certain counterparties or even only certain transactions or might be expanded to include decision making, recommendations on credit limits, and presenting to the credit committee.

Should the duties extend into the decision-making process, responsibilities would include the following: (1) authorizing the allocation of credit limits, (2) approving credit risk mitigants (i.e., guarantees, collateral), (3) approving excesses or exceptions over established credit limits, and (4) liaising with the legal department regarding transaction documentation.

Some analysts may be required to review and propose amendments to the bank's existing credit policies. With the implementation of the extensive regulatory requirements of Basel II and Basel III, credit analysts are now responsible for a wider range of regulatory compliance tasks.

Finally, counterparty credit analysts must understand the risks inherent with specific financial products and transactions. Therefore, it is necessary to obtain knowledge of the bank's products to supplement their credit decisions.

In an effort to make profits for the entity, **fixed-income analysts** provide recommendations regarding the decision to buy, sell, or hold debt securities. Therefore, they must ascertain the relative value to determine whether the security is undervalued, overvalued, or correctly valued. Both fundamental and technical analyses are generally performed in arriving at investment decisions. Fundamental analysis focuses on default risk while technical analysis focuses on market timing and pricing patterns. In making an investment decision, fixed-income analysts consider the ratings for specific debt securities issued by the rating agencies. The ratings provide reliable input in computing the relative value of securities.

**Equity analysts** analyze publicly traded financial institutions to help in determining whether an investor should buy, sell, or hold the shares of a given financial institution. When performing valuations, there is an emphasis on using return on equity (ROE). ROE takes into account both profitability and leverage. Other types of analysts would look at a wider range of financial ratios dealing with a bank's asset quality, capital strength, and liquidity. Equity analysts usually perform company valuations based on unaudited projections (while other analysts usually use audited historical data). Similar to fixed-income analysts, there are two general approaches to equity analysis. Analysts could choose to perform fundamental analysis, technical analysis, or a combination of the two.

## Banking Credit Analyst Skills

**LO 19.3: Describe the quantitative, qualitative, and research skills a banking credit analyst is expected to have.**

**Quantitative skills** are necessary to assist in determining the ability of the entity to repay debt. A banking credit analyst must be able to read and interpret financial statements in order to perform a wide range of ratio analysis. The ratios to be analyzed depend on which measures of financial performance are relevant (i.e., liquidity, solvency, profitability). For example, return on equity (ROE) is a commonly used measure because it considers efficiency and leverage in addition to profitability. Because of the standardized nature of financial performance measures, peer analysis (i.e., comparison with similar banks and financial institutions) is possible and can be used to compare financial results.

Analysts must also understand statistical concepts (e.g., sampling, confidence intervals, correlation) in order to properly interpret data to arrive at reasonable conclusions under uncertainty. An example of a statistical analytical tool would be trend analysis (comparison of current year performance to past performance). The ability to analyze asset quality is also important. For example, a banking credit analyst could quantitatively assess a bank's loan portfolio by computing nonperforming loan ratios. Finally, analysts should have an understanding of monetary policy and an ability to compute and interpret macroeconomic data (e.g., GDP growth rates), both of which impact the general banking industry.

**Qualitative skills** are necessary to assist in determining the willingness of the entity to repay debt (e.g., reputation, repayment track record). It is critical for analysts to think beyond numbers and apply considerable judgment, reasoning, and experience in determining which factors are relevant for making decisions (e.g., management competence, bank's credit culture, and the robustness of credit review process).

The ability to analyze the quality, reliability, and consistency of reported earnings is also necessary. In addition, an understanding of the regulatory environment of banks and the impact(s) of any regulatory changes is important (e.g., central bank given more authority to regulate banks).

An analyst should have basic **research skills** in order to analyze an unfamiliar banking sector. Some preliminary research on overall sector structure, sector characteristics, and nature of regulation should be performed first. Then a reasonably detailed review of the largest banks followed by smaller banks may be performed. Examining larger banks first provides a basis of comparison when subsequently looking at smaller banks. After gaining a

thorough understanding of the banking sector, a bigger-picture perspective might be taken. For example, an analyst might try to research the country's entire banking sector, making note of the dominant entities and their impact on the sector.

A rating agency analyst would most frequently utilize **primary** research skills while a counterparty credit analyst would most frequently utilize **secondary** research skills.

Primary research skills include detailed analysis of (audited) financial statements for several years together with annual reports and recent interim financial statements. In addition, the rating analyst would usually need to make one or more due diligence visits to the bank to meet with senior management to discuss operational and business strategy. In addition to the visit, a questionnaire may also be provided to management to complete and return to the analyst.

Secondary research skills involve using the research published by others (e.g., rating agencies). The counterparty credit analyst would not make frequent visits to banks. Any site visits would tend to be brief and focused on very specific areas.

## Information Sources

### LO 19.4: Assess the quality of various sources of information used by a credit analyst.

#### Annual Report

Although there is likely bias on the part of management to present the entity in the most favorable way, the annual report does contain some useful information about culture, strategy, company performance, and economic outlook in the Management Discussion and Analysis (MD&A). Other information pertaining to regulation, such as changes to accounting or banking rules, may also be present in the annual report.

#### Auditor's Report

The auditor of a bank's financial statements is usually a major international accounting firm, and the staff on the audit engagement would possess specialized knowledge of the accounting rules pertaining to banks in order to successfully audit the bank in question.

The auditor provides an independent opinion on the bank's financial statements. If an **unqualified opinion** (or clean opinion) is provided, then it means that the auditor accepts the financial statements prepared by management as meeting the minimum standards of presentation (i.e., no material misstatements). The opinion assumes that management has provided the auditors with accurate information. Because of the cost-benefit tradeoff of analyzing every single item, auditors utilize a sampling approach and/or focus on high-risk areas during the testing phase. As a result, the financial statements may not be perfect or 100% accurate, but they present a reasonable indication of the financial performance for the stated period (income statement) and financial condition at a given point in time (balance sheet). In addition, it is not the auditor's responsibility to detect fraud committed by the

audited bank. It is up to the analyst to verify that an unqualified opinion has been issued and to watch for any exceptions from the standard wording of an unqualified opinion.

Analysts should be cautious when a qualified opinion is issued. With a qualified opinion, the auditors are saying that the financial statements might not fairly represent the company's financial performance and condition. The wording will be clear in the final paragraph of the report, with the existence of the word *except*. Common reasons for a qualified opinion include (1) substantial doubt as to the bank's ability to continue as a going concern, (2) a specific accounting treatment used by management is inconsistent with accounting rules, and (3) significant amounts of related-party transactions. It is up to the analyst to investigate and determine the exact nature of the qualification, its severity, and its impact on the analyst's overall assessment.

Rarely will the auditors issue an **adverse opinion** where they state that the financial statements do not fairly present the bank's financial performance and condition.

Sometimes there will be a change in auditors, and it is up to the analyst to inquire and determine if the change was valid. For example, sometimes management will dismiss its auditors because of a disagreement over one or more accounting treatments or the auditor's unwillingness to provide an unqualified opinion. The analyst should generally look upon those situations unfavorably. Alternatively, it is sometimes mandatory in some countries for a change in auditors every few years because they may have developed a comfortable relationship with the audited entity, preventing them from demonstrating independence and objectivity. In such a situation, the change in auditors is valid.

### Financial Statements—Annual and Interim

The financial statements generally consist of the (1) balance sheet, (2) income statement, and (3) statement of cash flows. The balance sheet documents the net worth of the bank at a given point in time (e.g., year-end), and the income statement provides a quantification of performance over the period (e.g., net income for the year). The statement of cash flows is very useful for analyzing nonfinancial entities but not useful for bank credit analysis. An additional item, the statement of changes in capital funds, is useful for bank credit analysis (and regulatory purposes) because it explains changes in capital levels.

Supplementary footnotes to the financial statements may be included that provide more detail on specific items (e.g., off-balance sheet items such as leases and accounting policies).

Interim financial statements may be issued quarterly or semiannually, and they provide more timely financial information that would be useful to an analyst in making a current assessment of the bank.

### Bank's Website

On the bank's website, the analyst is often able to find valuable information such as the annual report, financial statements, press releases, and background information. The quality, layout, and ease of accessibility of the website itself are often good indications of the stability of the bank.

## News, the Internet, Securities Pricing Data

The analyst should check for any significant subsequent events (e.g., mergers, acquisitions, or new regulations) occurring after the corporate year-end that might not be covered in the annual report.

Proprietary electronic data services such as Bloomberg or a simple web search may provide necessary data on current bond and equity prices (especially for public listings or debt offerings).

## Prospectuses and Regulatory Filings

Prospectuses and regulatory filings tend to minimize the discussion of the benefits of the investment and emphasize more of the potential risks so they could provide some useful information. Notably, prospectuses for equity and international debt issues may provide an effective resource.

## Rating Agency Reports and Other Third-Party Research

As stated previously, counterparty credit analysts will find the rating agency reports most useful for their analysis. Other third party research includes investment reports from regulatory agencies and equity analysts.

# Key Concepts

## LO 19.1

Common credit analyst roles include consumer credit, credit modeling, corporate credit, counterparty credit, rating agency, fixed income, and bank examiner/supervisor. The roles are generally risk management in nature, although the fixed-income credit analyst focuses on investment selection. Primary and/or secondary research methods may be applied, and analysts could be analyzing nonfinancial entities, financial institutions, or sovereigns. Credit analysts are generally employed by banks, nonbank financial institutions, institutional investors, rating agencies, or government agencies.

## LO 19.2

A counterparty credit analyst may perform risk evaluations of a given entity on a transaction-by-transaction basis or through an annual review. At times, the duties may extend into decision making (e.g., authorizing credit limits, suggesting guarantees and collateral, authorizing excesses). Additionally, there may be duties related to examining and amending the bank's existing credit policies and compliance tasks related to Basel II and III.

Fixed-income and equity analysts provide recommendations whether to buy, sell, or hold securities. Both types of analysts use fundamental and/or technical analysis techniques. Fixed-income analysts focus on determining relative value while equity analysts focus on determining return on equity.

## LO 19.3

As a fundamental skill, banking credit analysts should be able to read and interpret financial statements in order to perform ratio analysis. They should also have a reasonable background in statistical concepts, in order to properly process and analyze data, and in macroeconomics, in order to understand the given bank's performance within the context of the overall economic environment. Additionally, significant judgment and skill in choosing relevant information to analyze is required in order to capture the important qualitative elements of any analysis.

## LO 19.4

The annual report, auditor's report, financial statements (annual and interim), bank's website, internet, rating agency reports, other third-party research, prospectuses, and regulatory filings are some of the many available sources of information that may be used by a credit analyst. The annual report, together with financial statements, is the usual starting point for the analyst. For example, a counterparty credit analyst will rely heavily on rating agency reports.

## Concept Checkers

1. Richard Marshall, FRM, is a rating agency analyst who is currently performing financial statement analysis on a major bank. Which of the following financial statements would be least useful for bank credit analysis?
   A. Balance sheet.
   B. Income statement.
   C. Statement of cash flows.
   D. Statement of changes in capital funds.

2. Krista Skujins, FRM, is a bank credit analyst who is examining the financial statements of a bank. She notices that there is a paragraph noted in the auditor's report that states that although the auditors agreed with virtually all of the bank's accounting treatments of the financial statement items, the auditors did not agree with the bank's decision to treat some of the leases as operating leases instead of capital leases. Based on that information, which of the following audit report opinions has the auditor most likely issued?
   A. Adverse opinion.
   B. Denial of opinion.
   C. Qualified opinion.
   D. Unqualified opinion.

3. Which of the following statements regarding a banking credit analyst's skills is most likely correct?
   A. High earnings quality suggests that the bank is profitable.
   B. Peer analysis is facilitated by the standardized nature of financial performance measures.
   C. Although qualitative analytical skills are required, quantitative analytical skills are more important.
   D. In analyzing an unfamiliar banking sector, an analyst should start by performing detailed reviews of the major banks.

4. Which of the following types of credit analysts would most likely be performing fundamental and/or technical analysis on a day-to-day basis?
   A. Equity analyst only.
   B. Fixed-income analyst only.
   C. Counterparty analyst and equity analyst.
   D. Equity analyst and fixed-income analyst.

5. Which of the following statements regarding the role of a corporate credit analyst is most likely correct?
   A. Earnings analysis is by far the most important analyst task.
   B. The larger the size of the firm, the lower the cost of analysis.
   C. Analysts are generally required to cover multiple industry areas given the huge diversity among corporations.
   D. The smaller the firm, the lower the cost of analysis.

## Concept Checker Answers

1. **C** Although the statement of cash flows is most useful for analyzing nonfinancial entities (uses of cash and sources of cash differentiated between operating, investing, and financing), it is not useful for bank credit analysis.

2. **C** This situation is one where a specific accounting treatment used by the bank's management is inconsistent with the accounting rules. It is an isolated instance and so a qualified opinion would most likely be issued.

3. **B** Peer analysis refers to the comparison (financial and creditworthiness) of a subject bank to similar banks and financial institutions.

   High earnings quality does not necessarily mean a bank is profitable. Earnings quality refers to the reliability and consistency of the reported earnings.

   Quantitative and qualitative analytical skills are equally important and serve different (but related) purposes; qualitative skills are necessary to assist in determining the *willingness* of an entity to repay debt while quantitative skills are necessary to assist in determining the *ability* of an entity to repay debt.

   In analyzing an unfamiliar banking sector, the analyst should start with preliminary research on the overall structure, characteristics, and nature of regulation. After that, a detailed review of the largest (followed by smaller) banks could be performed.

4. **D** Both fixed-income analysis and equity analysis can be divided into two broad approaches: fundamental and technical analysis. Those approaches are valid because both types of analysts have the objective to earn profits for their respective employers and/or clients. In contrast, counterparty credit analysts are not likely to use either approach and are more focused on performing risk evaluations and possibly making some decisions on granting credit.

5. **B** With a large public company, there may be a lot of publicly available information that would only necessitate secondary research, thereby reducing costs. With a smaller private company, less information is likely available, and, as a result, more due diligence and primary research would be required, thereby increasing costs.

   Although the basic analytical principles are the same, there is huge diversity in the business sectors, products, size, and geographic locations of the firms being analyzed. As a result, the corporate credit analyst must possess specific industry knowledge in order to be effective. An analyst will most likely focus on only one or two industry areas.

   Corporate credit analysts specifically analyze firms that are NOT financial institutions.

   Cash flow analysis, not earnings analysis, is key to assessing corporate credit risk.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Default Risk: Quantitative Methodologies

Topic 20

## Exam Focus

In this topic, we will discuss methods for computing default risk. The Merton model estimates the value of the bondholder and stockholder claims, which are then used to calculate the implied probability of default. However, this model requires many unrealistic assumptions. Moody's KMV model relaxes some of these assumptions. Other methods used to predict default are credit scoring models, including parametric methods and nonparametric methods. Note that the Merton model and the KMV model will be discussed in greater detail in the next topic (Topic 21). For the exam, understand how the KMV model calculates probability of default and have a general understanding of the credit scoring models discussed.

## The Merton Model

**LO 20.1: Describe the Merton model for corporate security pricing, including its assumptions, strengths and weaknesses:**

- **Illustrate and interpret security-holder payoffs based on the Merton model.**
- **Using the Merton model, calculate the value of a firm's debt and equity and the volatility of firm value.**
- **Describe the results and practical implications of empirical studies that use the Merton model to value debt.**

*Professor's Note: The last two bullet points from LO 20.1 will be addressed in Topic 21.*

**Structural models** of credit risk estimate default risk as a function of the value of the firm. Given the value of the firm, the value of debt and equity can be determined. Structural models in this context are also called **value-based models**.

The **Merton model** is considered a value-based model, where the value of the firm's outstanding debt ($D$) and equity ($E$) are equal to the value of the firm ($V$). Given an estimate of any two of the three values ($V$, $E$, or $D$), we know the value of the third component. For example, given the fundamental value of the firm and the observed value of the stock, an analyst can determine the value of the bonds: D = V – E. Also, given $V$ and other information, $D$ and $E$ can be determined. The value of the debt can serve as an indicator of the firm's *default risk*.

Since $E$ and $D$ are contingent claims, option pricing can be used to determine their values. The Merton model assumes that the debt consists of a single zero-coupon bond issue that

matures at time *M* at face value $D_M$. At the maturity of the debt, if the value of the firm's assets is less than the value of the debt, then the firm must default. The debtholders get the value of the firm, and they either break even or take a loss, while the equityholders get nothing. The payoffs at maturity are as follows:

payment to debtholders = $D_M - \max(D_M - V_M, 0)$

payment to stockholders = $\max(V_M - D_M, 0)$

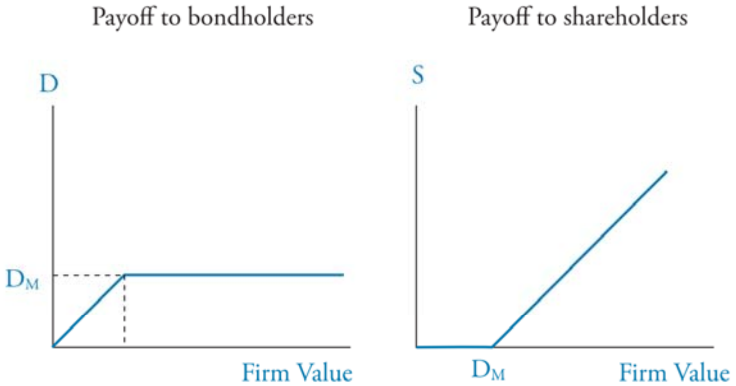
The Merton model assumes that *V* follows a certain distribution over time, such that the value of the stockholders' claim can be determined by the Black-Scholes-Merton option pricing model. This is because the payment to the stockholders at maturity is like the payoff of a long position in a call option. The payoff of a call option is denoted with the following expression: max(price of stock – exercise price, 0). The debtholders' payoff resembles that of a short put and risk-free bond.

The relationship of the Merton model to the Black-Scholes-Merton model requires some other strong assumptions (e.g., the bondholders cannot force bankruptcy prior to maturity; the value of the firm, *V*, is observable and follows the assumed time-series process; etc.).

If we can assume the Merton model is valid and that the assumptions hold, we can use the previous equations to compute the payoffs. For example, we will assume the bonds have a maturity, or face value, of $80. If we consider a case where the value of the firm is $200 when the bonds mature, then the payoff to stockholders is $120, and the payoff to bondholders is $80. In another case, if the value of the firm is $70, then the debtholders get $70, and the stockholders get $0. These results require the assumption that no adjustment for liquidity is needed.

Diagrams of the payoffs resemble those of option payoffs. Figure 1 shows that the payoff to bondholders (*D*) increases one-for-one with the value of the firm (*V*), $D = V$, until $V > D_M$, when the maximum payoff to the bondholders ($D_M$) is reached. The payoff to shareholders (*S*) begins at the point where $V = D_M$ and increases dollar-for-dollar with the firm value for firm values above $D_M$. It can be viewed as a call option on firm value with an exercise price of $D_M$, the maturity value of the debt.

**Figure 1: Payoff to Bondholders and Shareholders at Maturity**



The strengths of the Merton model are its simplicity when pricing corporate debt, as well as its intuitive nature. The weaknesses are the number of assumptions required, as well as some practicality issues. For example, the absence of marked to market debt values makes it difficult to accurately value the firm. In addition, it can also be difficult to find an accurate estimate of asset volatility.

## The KMV Approach

Banks use the Merton and the KMV approach to determine default rates. Default rate information is necessary to determine the required capital needed to cover losses. The following is a discussion of the sources of error in the determination of default rates using these methods.

The Merton model uses market data such as stock value and capital structure to predict rates of default. The Merton model relies on a list of unrealistic assumptions:

1. There is only one issue of equity and debt, and the debt is in the form of a zero-coupon bond that matures at a given date.
2. Default can only occur at the maturity date.
3. The value of the firm is observable and follows a lognormal diffusion process (geometric Brownian motion).
4. The risk-free interest rate is constant through time.
5. There is no negotiation between equity and bondholders.
6. There is no need to adjust for liquidity.

The **KMV model** is built on the Merton model and tries to adjust for some of the shortcomings, most notably (1) that all the debt matures at the same time and (2) that the value of the firm follows a lognormal diffusion process.

The KMV model assumes that there are only two debt issues; the first matures before the chosen horizon, and the other matures after that horizon. The maturity value, or **default threshold**, is a linear combination of the values. The default threshold (a.k.a. the default point) is in essence the par value of the firm's liabilities (or debt). In other words, the default threshold is a combination of short-term and long-term liabilities.

A practical rule for determining the default point (i.e., default threshold) is:

short-term liabilities + 0.5 × long-term liabilities.

This equation is applicable when the ratio of long-term-liabilities-to-short-term-liabilities is less than 1.5. If this ratio is greater than 1.5, the default point would be determined as follows:

$$\text{short-term liabilities} + \left(0.7 - \frac{0.3 \times \text{short-term liabilities}}{\text{long-term liabilites}}\right) \times \text{long-term liabilites}$$

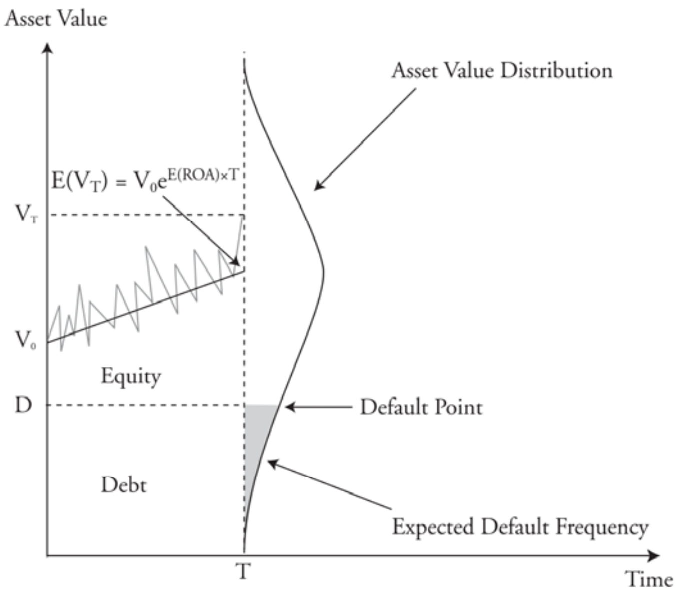
Before we can calculate the probability of default using the KMV model, we must derive the distance to default (DD). The DD considers the distribution of the firm's asset returns and calculates the number of standard deviations between the mean of the asset distribution and the default threshold. In equation form:

$$DD = \frac{\text{expected asset value} - \text{default threshold}}{\sigma_{\text{expected asset value}}}$$

*Professor's Note: On previous FRM exams, the distance to default has been calculated using the following expression: (asset value – liability value) / (standard deviation of asset value in dollar terms).*

Once the distance to default is computed, the expected default frequency (a.k.a. the probability of default) can be found. We will soon see how the expected default frequency figure is mapped onto a credit rating system to identify the rating of a particular firm.

**Figure 2: Distance to Default**



Since asset prices are lognormally distributed, the DD is more precisely calculated using the following formula at time horizon *T*:

$$\mathrm{DD} = \frac{\log(\mathrm{V}) - \log(\text{default threshold}) + \left[\mathrm{E(ROA)} - \frac{\sigma_{\mathrm{v}}^2}{2}\right] \times \text{maturity}}{\sigma_{\mathrm{v}} \times \sqrt{\text{maturity}}}$$

where:
E(ROA) = expected return on assets
V = value of the firm assets
$\sigma_{\mathrm{v}}$ = standard deviation of firm assets

*Professor's Note: "log(V) – log(default threshold)" in the equation above can also be written as "log(V / default threshold)." Also, recall that the value of the firm (i.e., value of assets) is made up of both debt and equity. Therefore, like the Merton model, one of the main drivers of the KMV model is equity prices (i.e., stock prices).*

This equation will also be seen in Topic 21 when we examine the probability of default using the Merton model. The difference, however, between Merton and KMV is how this equation is utilized. As you will see in the next topic, the Merton model computes the cumulative normal distribution for the negative value of the previous DD expression. For example, if the expression equals 1.96, the Merton model would say that there is N(–1.96) = 0.025 or 2.5% probability of default. Note that this value is found by using the cumulative normal distribution table (i.e., cumulative z-table) in the appendix of this book.

The KMV model on the other hand, uses the same distance to default value (e.g., 1.96) and assesses the number of defaults at a later date (e.g., 1 year) associated with the computed DD value. The number of defaults from a given sample of firms is then used to compute the **expected default frequency** (EDF). Again, EDF in the KMV model is also known as the probability of default. The EDF will be associated with a particular credit rating (e.g., BBB). The following example will help illustrate the calculation of expected default frequency.

**Example: Expected default frequency**

Assume the expected asset value in one year from the asset value distribution is $800, and the default threshold is found to be $500. **Calculate** the distance to default if the annual asset standard deviation is 100.

**Answer:**

$$DD = \frac{800 - 500}{100} = 3$$

To compute EDF, assume that 2,000 firms last year had a DD of 3, and 15 of these firms defaulted after one year. The expected default frequency = 15/2,000 = 0.75%. This value is associated with the EDF of the firm since this firm also has a DD of 3. An implied credit rating is then assigned based on this EDF value. For example, a low EDF, such as 0.75%, would be assigned an AA-rating.

The calculation of EDF is a valuable leading indicator of default and oftentimes predicts default months in advance. A sharp increase in the slope of the expected default frequency is a good indicator that a credit rating downgrade is likely to occur in the near future.

## Credit Scoring Models

### LO 20.2: Describe key qualities of credit scoring models.

Credit scoring models assign a numerical value to a firm, which indicates whether a firm is likely to default or not. Their main function is to assess the creditworthiness of small and private firms. For example, credit scores enable small businesses to gain approval for loans in a shorter amount of time. Features of optimal credit scoring models include the following:

- **Accuracy** – produces a low volume of errors.
- **Parsimony** – uses a limited number of independent variables.
- **Non-triviality** – produces appealing outcomes.
- **Feasibility** – uses accessible resources in a reasonable amount of time.
- **Transparency** and **Interpretability** – data is easy to find and interpret.

### LO 20.3: Compare the following quantitative methodologies for credit analysis and scoring: linear discriminant analysis, parametric discrimination, K nearest neighbor approach, and support vector machines.

**Fisher linear discriminant analysis**. A process that segregates a larger group into homogeneous subgroups. The larger group could be potential borrowers, for example, and the subgroups could be good and bad borrowers. An example of linear discriminant analysis is Altman's Z score.

**Parametric discrimination**. A particular approach to discriminant analysis that uses a score function to determine the members of the subgroups. Examples of parametric discrimination are logit and probit models. Parametric discriminant analysis determines a score using a regression, logit, or other statistical technique. Whether the value of the score falls above or below a certain threshold determines which subgroup the observation is placed in (e.g., whether a firm is categorized into a likely-to- or not-likely-to-default group).

*Professor's Note: Logit models are based on linear probability models, which restrict the range of the default probability to be between 0 and 1.*

**K-nearest neighbor**. A nonparametric discriminant technique that uses the properties of firms that have already fallen into the categories of interest (e.g., default or not default) and categorizes a new entrant by how closely it resembles the members already in each of the groups.

**Support vector machines**. A method that uses the characteristics of observations (firms) to create an equation that does the best job of dividing the larger group into two subgroups. The groups can be linear and include planes and hyperplanes. They can be nonlinear where the separation criteria is a polynomial.

## Decision Rules in Credit Analysis

**LO 20.4: Differentiate between the following decision rules: minimum error, minimum risk, Neyman-Pearson and Minimax.**

Decision rules, as used in credit analysis, categorize patterns of descriptive variables, such as leverage and earnings measures, that would then place an observation (e.g., a firm) into a group (e.g., a high-risk- or a low-risk-of-default group).

**Minimum error** is a decision rule that uses Bayes' theorem to determine a probability. It forms a conditional probability of a firm being in one group or another given its characteristics, denoted *C*, and the highest conditional probability determines the group to which the firm is assigned. The decision basically becomes one where the user would compute the probabilities in the following expression:

p(C given default) × p(default) > or < p(C given not default) × p(not default)

If the left is greater than the right, then *C* would indicate that the firm should be in the likely-to-default group. If the inequality is reversed, then the characteristics would indicate that the firm should be in the not-likely-to-default group.

**Minimum risk** refers to a class of rules that try to either minimize the probability of misclassification (incorrectly lending to risky firm) or minimize the loss associated with that error.

**Neyman-Pearson** is a decision rule that uses the statistical concept of Type I and Type II errors. A Type I error is lending to a risky firm because it was incorrectly accepted as a non-risky firm. A Type II error is not lending to a non-risky firm because it was incorrectly rejected as being risky. The procedure first requires that the user select a fixed value for the probability of a Type II error and places it in a Lagrangian multiplier equation that

determines a threshold value. For any given set of firm "characteristics," the decision is to not extend a loan to the firm if the following holds:

$$\frac{p(\text{"conditions" given default})}{p(\text{"conditions" not given default})} > \text{threshold value}$$

**Minimax** is a decision rule of minimizing the maximum error or risk. Using Type I and Type II errors as examples, the goal is to minimize the maximum of the two. In a case such as this where there are only two types of errors, the minimum is obtained by determining a set of criteria where the cutoff makes the probability of the two types of errors equal to each other.

In summary, the minimum error rule makes a decision based on calculated probabilities. The other three methods use optimization techniques to determine a classification system that reduces the probability of error and/or loss.

## Measures of Performance

**LO 20.5: Identify the problems and tradeoffs between classification and prediction models of performance.**

**LO 20.6: Describe important factors in the choice of a particular class of model.**

The **receiver operating characteristic** (ROC) evaluates a credit decision rule by computing (1) the proportion of correctly predicted defaults and (2) the proportion of firms that were predicted to default and did not:

1. $Y = \dfrac{\text{number of defaults correctly predicted}}{\text{number of defaults}}$

2. $X = \dfrac{\text{number of firms predicted to default and did not}}{\text{number of firms that did not default}}$

The Y and X symbols have been applied to indicate how the results would appear on a two-dimensional graph. The graphical representation would have a maximum value of unity (i.e., 1) for both the X- and Y-axes. The X-axis corresponds to the proportion of incorrectly predicted defaults, and the Y-axis corresponds to the proportion of correctly predicted defaults. The slope of the ray from the origin to the point representing the plot of the two values is the performance measure. Ideally, the ray should have an infinite slope; this occurs if all defaults were correctly predicted and there were no predictions of default that did not occur. If the ray has a 45-degree slope, then there were equal proportions of types of mistakes.

The **cumulative accuracy profile**, or CAP (also called GINI curve), compares the probabilities of default computed by the classification system to the ranking of observed defaults. It uses a graphical system similar to that of the ROC. The vertical axis represents the fraction of firms that actually defaulted, and the horizontal axis represents the probabilities computed by the classification system. The shape of the line on the graph indicates the success of the classification system.

Both of the measures compare predictions made by a default/not-default classification system to the realized pattern of defaults. The ROC uses the raw ratios computed from correct and incorrect predictions. In contrast, the CAP incorporates the individual value of the probability of default of each of the firms in the overall analysis. In both cases, assessing the performance involves plotting the results on a graph and interpreting the resulting pattern.

Classification models will suffer from measurement error and statistical sampling error. Any probability computed from a sample is a sample estimate of a population parameter, so sampling error will always be present. The inputs, such as the financial ratios, might be calculated using different methods, which can introduce problems as well.

In selecting and using the models, two general tradeoffs need to be addressed: performance versus complexity and data availability versus data quality. Presumably, a more complex model would have a higher level of performance, but the complexity may make it more time-consuming and less understandable. Some models require a minimum sample size in the estimation, and there may be a tendency to add data points where the information quality is low.

Other factors to consider when choosing between the models are as follows:

- How easy the model is to understand.
- How robust the model is when new data is added into the analysis.
- The time to calibrate and recalibrate the model.

For example, a researcher may wish to use an easily understood model, yet she may have to choose a model that is very complex and takes a long time to calibrate because it gives the most accurate results.

It is often recommended that an analysis of creditworthiness employ more than one model in order to compare the results. Backtesting and assessment will help in choosing and calibrating the appropriate models.

# Key Concepts

### LO 20.1

The Merton model uses the Black-Scholes-Merton option pricing model to assess the value of a firm's stocks and bonds and to compute the probability of default. The Merton model has some unrealistic assumptions.

Security payoffs using the Merton model resemble those of options. For example, the stock payoff is like that of a long call, and the bond payoff is like that of a short put and risk-free bond.

### LO 20.2

Credit scoring models assign a numerical value to a firm, which indicates whether a firm is likely to default or not. Factors of credit scoring models include: accuracy, parsimony, non-triviality, feasibility, transparency, and interpretability.

### LO 20.3

There are several types of parametric discriminant analysis techniques that compute a score based on a scoring model, such as regression or logit model. The score assigned to the firm determines its classification. Other methods of classification determine boundaries for classification based on the characteristics of the observations. They include k-nearest neighbor and support vector machines.

### LO 20.4

Decision rules for determining if a firm is a high-risk, likely-to-default firm include minimum error, minimum risk, Neyman-Pearson, and minimax. The minimum error rule simply computes a pair of probability values for each firm and makes a decision based on which probability is the larger of the two. The other three methods use optimization techniques to develop criteria with the goal of minimizing the expected number of incorrect decisions, losses, or both.

### LO 20.5

In addition to the usual estimation problems, such as sampling error and measurement problems, the use of classification models has other considerations, including robustness to new data, ease of interpretation, ease of use, and recalibration. There are also tradeoffs between complexity versus performance and data availability versus data quality.

### LO 20.6

The receiver operating characteristic (ROC) and cumulative accuracy profile (CAP) compare predictions made by a default/not-default classification system to realized patterns of defaults. The ROC reports a result based on the raw ratios computed from correct and incorrect predictions. The CAP compares the pattern of defaults to the distribution of the probabilities computed.

## Concept Checkers

1. All of the following are assumptions of the Merton model except:
   A. the risk-free rate is perfectly collinear with the value of the firm.
   B. default can only occur when the bond matures.
   C. bond and stockholders cannot negotiate.
   D. there is no need to adjust for liquidity.

2. The KMV model:
   A. assigns a probability to a firm to indicate its likelihood of default by using the cumulative normal distribution, like the Merton model.
   B. assigns a probability to a firm to indicate its likelihood of default by using the cumulative normal distribution, which distinguishes it from the Merton model.
   C. does not use the cumulative normal distribution to assign a probability to a firm to indicate its likelihood of default, which distinguishes it from the Merton model.
   D. does not use the cumulative normal distribution to assign a probability to a firm to indicate its likelihood of default, like the Merton model.

3. A firm's assets are currently valued at $700 million, its current liabilities are $120 million, and long-term liabilities are $300 million. The standard deviation of expected asset value is $76 million. Assume the firm has no other debt and that the ratio of long-term-liabilities-to-short-term-liabilities is less than 1.5. What will be the appropriate distance to default measure when utilizing Moody's KMV Credit Monitor Model?
   A. 9.21 standard deviations.
   B. 5.66 standard deviations.
   C. 3.68 standard deviations.
   D. 1.87 standard deviations.

4. Using the properties of firms that have already fallen into default/non-default groups to categorize a new observation by how closely it resembles the members already in each of the groups is referred to as:
   A. linear discriminant analysis.
   B. the k-nearest neighbor approach.
   C. support vector machines.
   D. None of the above.

5. Which of the following includes models in which the assigned score can be interpreted as a probability of default?
   A. Parametric discrimination.
   B. The k-nearest neighbor approach.
   C. Support vector machines.
   D. None of the above.

## Concept Checker Answers

1. **A** The Merton model assumes that the risk-free interest rate is constant through time.

2. **C** The Merton model uses the cumulative normal distribution to determine the probability of default. The KMV model uses a proprietary algorithm that is not known to the public.

3. **B** The KMV calculation is as follows:

   Distance to default = (asset value – liability value) / standard deviation of asset value

   Liability value = short-term (or current) liabilities + 0.5 × long-term liabilities

   Distance to default = [\$700m – (\$120m + 0.5 × \$300m)] / \$76m

   Distance to default = 5.66 standard deviations

4. **B** K-nearest neighbor is a nonparametric discriminant technique that uses the properties of firms that already have fallen into the categories of interest, and it categorizes a new entrant by how close it resembles the members already in each of the groups.

5. **A** Parametric discrimination is the use of an equation to assign a value to firms, and that value would indicate whether it falls into a default or non-default category. Included in this category of scoring models is the logit model, in which the score can be interpreted as a probability.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Credit Risks and Credit Derivatives

Topic 21

## Exam Focus

The potential failure of a party to fulfill an agreed-upon payment is an uncertainty for risk managers. The pricing of risky debt using the Merton model provides insight into predicting the probability of default and the amount of loss should default occur. Additional approaches have been developed to evaluate the credit risk of portfolios and provide estimates of a portfolio's credit value at risk. Credit derivatives provide the risk manager with financial instruments that are used to hedge credit risk exposures. This topic presents several models for evaluating and measuring credit risk, along with examples of credit derivatives used to hedge credit risk exposure. For the exam, be sure to understand the calculation of firm equity and debt under the Merton model.

Credit risk refers to the chance that a party will fail to make promised payments. Risk managers assess credit risk and determine its potential impact on income and if it should be hedged using derivatives contracts or some other means.

The two important roles that credit risk plays in risk management programs are (1) assessing the potential of default by debt claimants and (2) assessing the potential of default by counterparties of derivatives contacts.

Derivative contracts with payoffs dependent on a specified credit event are called **credit derivatives**. Risk managers use credit derivatives to hedge their exposure to credit risk.

## The Merton Model

The Merton model, based on Black-Scholes-Merton option pricing theory, evaluates various components of firm value. The simplest form of the model assumes the existence of a non-dividend paying firm with only one liability claim and that financial markets are perfect. That is, the model assumes away taxes, bankruptcy costs, and costs associated with enforcing contracts.

Suppose that the firm's only debt issue is a zero-coupon bond with a face value (or principal amount) of $F$, due at the maturity date of $T$. If the firm is unable to pay the principal at $T$, then the firm is bankrupt and the equity claimants receive nothing. Alternatively, if the firm value at $T$, $V_T$, is large enough to pay the principal amount, then equity holders have claim to the balance, $V_T - F$. These two payoff possibilities are the same as the payoffs for a call option, with the firm value as the underlying asset and the principal amount as the exercise price. Therefore, the value of equity at $T$ is:

$$S_T = \text{Max}(V_T - F, 0)$$

**Example: Computing the value of equity**

**Calculate** the value of the firm's equity at $T$, $S_T$, given that principal amount due on the zero-coupon bond is \$50 million and the total value of the firm at $T$, $V_T$, is \$60 million. In addition, what is the value of equity if $V_T$ is \$40 million?

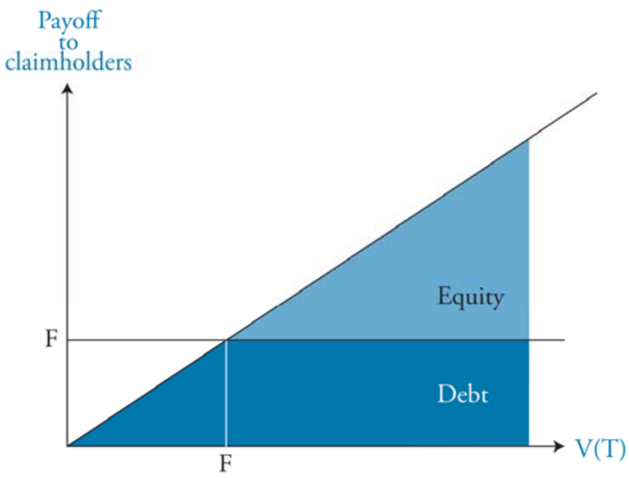
**Answer:**

$$S_T = \text{Max}(60 - 50, 0) = 10 = \$10 \text{ million}$$

$$S_T = \text{Max}(40 - 50, 0) = 0 = \$0 \text{ million}$$

Figure 1 depicts the payoffs at $T$ of the claimholders relative to the total firm value. The shape of the payoff for equity is the same as the payoff of a long call option. The payoff for debt is similar to that of a risk-free bond and a short position in a put option, but the uncertainty of the payoff requires some additional analysis.

**Figure 1: Debt and Equity Payoffs When Debt is Risky**




If the debtholder knew with certainty that he would receive the principal amount at the maturity for the zero-coupon bond, then the payoff would be $F$ regardless of the firm value. However, the debtholder cannot expect to receive $F$ if the total value of the firm, $V_T$, is less than $F$. Therefore, if $F > V_T$ then the amount received by the debtholder will be reduced by $F - V_T$. This payoff is the same as buying a Treasury bill with a face value of $F$ and selling a put on the firm value with an exercise price of $F$. Therefore, the value of debt at $T$ is:

$$D_T = F - \text{Max}(F - V_T, 0)$$

**Example: Computing the value of debt**

**Calculate** the value of the firm's debt at $T$, $D_T$, given that principal amount due on the zero-coupon bond is \$50 million and the total value of the firm at $T$, $V_T$, is \$40 million. In addition, what is the value of debt if $V_T$ is \$60 million?

**Answer:**

$$D_T = 50 - \text{Max}(50 - 40, 0) = 50 - 10 = 40 = \$40 \text{ million}$$

$$D_T = 50 - \text{Max}(50 - 60, 0) = 50 - 0 = 50 = \$50 \text{ million}$$

Since we know that the value of the debt plus the value of equity must be equal to the total value of the firm, alternative valuation formulas can be developed. For example, since the value of the firm at $T$ is:

$V_T = D_T + S_T$ then the value of debt at $T$ can also be written as:

$D_T = V_T - S_T$ and by substitution:

$$D_T = V_T - \text{Max}(V_T - F, 0)$$

Therefore, the value of debt is also the difference between the value of the firm and the call option on the value of the firm with $F$ as the exercise price.

The Black-Scholes-Merton option-pricing model for European options can be modified to determine the value of equity prior to $T$, $T - t$, if additional assumptions are made, which include:

- Firm value characterized by a lognormal distribution with constant volatility, $\sigma$.
- Constant interest rate, $r$.
- Perfect financial market with continuous trading.

## The Value of Equity at Time *t*

Using arbitrage pricing for a portfolio of securities that replicates the value of the firm results in Merton's formula for the value of equity such that:

$$S_t = V \times N(d) - Fe^{-r(T-t)} \times N(d - \sigma\sqrt{T-t})$$

where:

$$d = \frac{\ln\left(\frac{V}{Fe^{-r(T-t)}}\right)}{\sigma\sqrt{T-t}} + \frac{1}{2}\sigma\sqrt{T-t}$$

V = value of the firm
F = face value of the firm's zero-coupon debt maturing at *T* (only liability)
σ = volatility of the value of the firm
r = annual interest rate
N(d) = cumulative normal distribution function evaluated at *d*

**Example: Compute the value of equity**

Using the Merton model, **calculate** the value of the firm's equity at *t* given that the current value of the firm is $60 million, the principal amount due in 3 years on the zero-coupon bond is $50 million, the annual interest rate, *r*, is 5%, and the volatility on the firm, σ, is 10%.

**Answer:**

$$S_t = 60 \times N(d) - 50e^{-0.05(3)} \times N(d - \sigma\sqrt{T-t})$$

$$d = \frac{\ln\left(\frac{60}{(50)(0.8607)}\right)}{(0.10)\sqrt{3-0}} + \frac{1}{2}(0.10)\sqrt{3-0} = \frac{\ln(1.3942)}{0.1732} + \frac{1}{2}(0.1732) = 2.005$$

$$S_t = 60 \times N(2.005) - 50 \times 0.8607 \times N(2.005 - 0.1732)$$

*Professor's Note: N(d) can be found in a table of probability values (the z-table in the appendix).*

$$S_t = 60 \times 0.9775 - 43.035 \times 0.9665 = 58.650 - 41.593 = 17.057$$

Therefore, the value of equity of the firm is $17.057 million.

### The Value of Debt at Time *t*

There are two methods for valuing risky debt in this framework. Risky debt is equal to:

- Risk-free debt minus a put option on the firm.
- Firm value minus equity value.

**Example: Compute the value of debt**

**Calculate** the current value of the firm's debt as a portfolio of risk-free debt and a short position in a put on firm value with an exercise price of the face value of debt. Assume that the current value of the firm is \$60 million, the principal amount due in three years on the zero-coupon bond is \$50 million, the annual interest rate is 5%, and the volatility on the firm, $\sigma$, is 10%. Recall from the previous example that the value of equity is \$17.057 million.

**Answer:**

$$D_t = Fe^{-r(T-t)} - p_t$$

$$D_t = 50 \times e^{(-0.05)(3)} - p_t$$

$$D_t = 50 \times 0.8607 - p_t$$

$$D_t = 43.035 - p_t$$

Using put-call parity, the value of the put is:

$$p_t = c_t + Fe^{-r(T-t)} - V$$

$$p_t = c_t + 43.035 - 60$$

$$p_t = 17.057 + 43.035 - 60 = 0.092$$

$$D_t = 43.035 - p_t = 43.035 - 0.092 = 42.943$$

Therefore, the value of the debt issue is \$42.943 million.

**Example: Compute the value of debt**

**Calculate** the current value of the firm's debt as the difference between the total firm value and the value of equity priced as a call option. Assume that the current value of the firm is \$60 million, the principal amount due in three years on the zero-coupon bond is \$50 million, the annual interest rate is 5%, and the volatility on the firm, σ, is 10%.

**Answer:**

$$D_t = V - S_t$$

$$D_t = 60 - 17.057 = 42.943$$

Again, the value of debt is \$42.943 million.

Figure 2 shows the general relationships between debt and equity values according to the inputs of the Merton model.

**Figure 2: Relationships Between Debt and Equity Values as Compared to the Inputs of the Merton Model**

| | *Value of Firm, V* | *Face Value of Debt, F* | *Time to Maturity, T* | *Interest Rate, r* | *Volatility of the Firm, σ* |
|---|---|---|---|---|---|
| Value of debt | + | + | – | – | – |
| Value of equity | + | – | + | + | + |

## Credit Spreads, Time to Maturity, and Interest Rates

### LO 21.1: Explain the relationship between credit spreads, time to maturity, and interest rates.

A **credit spread** is the difference between the yield on a risky bond (e.g., corporate bond) and the yield on a risk-free bond (e.g., T-bond) given that the two instruments have the same maturity. For example, if a corporate bond is yielding 7% and the yield on the T-bond with the same maturity is 5%, the credit spread would be equal to 2%. This spread indicates that a higher yield is received for taking on increased risk.

The credit spread can be calculated using the following formula:

$$\text{credit spread} = -\left[\frac{1}{(T-t)}\right] \times \ln\left(\frac{D}{F}\right) - R_F$$

where:
$(T - t)$ = remaining maturity
$D$ = current value of debt
$F$ = face value of debt
$R_F$ = risk-free rate

For a given risky bond, the most you can receive is the par value at maturity. However, as time increases there is greater probability that the value received will be less than par. Studies have shown that as time to maturity increases, credit spreads tend to widen (i.e., increase). This applies to both high-rated and low-rated debt. However, for very risky debt, it may be the case that credit spreads narrow since there is a greater chance of payment as maturity approaches.

In addition to time to maturity, interest rates can also impact credit spreads. As the risk-free rate increases, the expected value of the firm at maturity increases, which in turn decreases the risk of default. A reduction in the risk of default will narrow (i.e., decrease) credit spreads.

## Determining Firm Value and Volatility

Since there is no single claim for the value of a levered firm, the value of the firm is unobservable. Further, it is virtually impossible to directly trade the value of the firm. These deficiencies can be solved using the Merton model if we assume that small changes in the return on equity are perfectly correlated with the value of the firm.

A portfolio consisting of a call option on the firm and a risk-free asset is equivalent to the value of the firm. Thus, a small change in firm value will change the value of equity by delta, Δ, times the change in firm value. Delta is the rate of change in the value of the call option relative to the change in the value of the underlying asset, ΔS/ΔV. The Merton model delta, Δ, is equal to N(d). Therefore, if we know the parameters for calculating the value of equity as a call and the value of risk-free debt, then we can determine the firm's value and the volatility of firm value.

**Figure 3: Low Firm Values and High Firm Values Using the Merton Model**

| | *Low Firm Values* | | | *High Firm Values* | | |
|---|---|---|---|---|---|---|
| Value of firm per share | 2.50 | 3.00 | 3.60 | 25.00 | 30.00 | 36.00 |
| Value of equity per share, $S_t$ | 0.196 | 0.306 | 0.469 | 15.659 | 20.164 | 25.723 |
| Change in value of equity if value of firm increases by 20% | --- | 56.1% | 53.3% | --- | 28.8% | 27.6% |
| Delta | 0.197 | 0.245 | 0.299 | 0.886 | 0.914 | 0.937 |

Although delta is increasing as the value of the firm increases, the change in the value of equity decreases as firm value increases. This indicates that the distribution of equity values

is not constant (which is sometimes referred to as a volatility smirk). The non-constant volatility of equity is a violation of the Black-Scholes-Merton model.

The **Geske compound option model** is appropriate for valuing the equity call option because it assumes that the value of the firm is characterized by a lognormal distribution with a constant variance.

If we know the value of equity and the value of an option on firm equity, we can use an iterative process to solve for firm value and firm volatility. A value for firm volatility and firm value is selected, and a value for equity is estimated using the Black-Scholes-Merton model. The same values for firm volatility and firm value are used in the compound option model to arrive at a value for the call option on equity. The outputs of the two models are then compared to actual values of equity and equity call option. Adjustments are made to firm value and firm volatility until the outputs of both models are the same as the actual values.

For example, suppose that the value of the firm is selected to be $25 per share, the volatility, $\sigma$, is 50%, the value of the call option using the compound option model is $6.0349 and the value of equity from the Merton model is $15.50. Also suppose the actual call option price is $6.72 and the actual equity price is $14.10.

Since the value of the option of $6.0349 is below $6.72 and the value of equity per share is above the observed price per share of $14.10, the firm value is too high and the volatility of the firm is too low. To decrease the value of equity from the Merton model, the value of the firm should be lower. To increase the value of the call option using the compound option model, the volatility measure needs to be higher. The results of the iterative process indicates that a firm value of $21 per share and a firm volatility of 68.36% produces model values that are equal to the observed values.

## Subordinate Debt

**LO 21.2: Explain the differences between valuing senior and subordinated debt using a contingent claim approach.**

**LO 21.3: Explain, from a contingent claim perspective, the impact of stochastic interest rates on the valuation of risky bonds, equity, and the risk of default.**

In the event of bankruptcy, subordinate debt will receive payment only after all obligations to senior debt have been paid. Because of the uncertainty associated with financial distress, the value of subordinate debt acts more like an equity security than a debt security. Therefore, when a firm is in financial distress, the value of subordinate debt will increase as firm volatility increases, while the value of senior debt will decline.

Suppose a firm has one issue of subordinate debt (SD) and one issue of senior debt (D) where both issues have the same maturity date, *T*. *F* and *U* represent the face values of senior debt and subordinate debt, respectively. Equity, *S*, is valued as a call option on the value of the firm, *V*, with an exercise price of F + U.

Subordinate debt can be valued in a portfolio as a long position in a call option on the firm with an exercise price equal to the face value of senior debt, *F*, and a short position on a call option on the firm with an exercise price equal to the total principal due on all debt, U + F. Figure 4 illustrates the portfolio payoffs for the previous equations.

**Figure 4: Subordinated Debt Payoff**

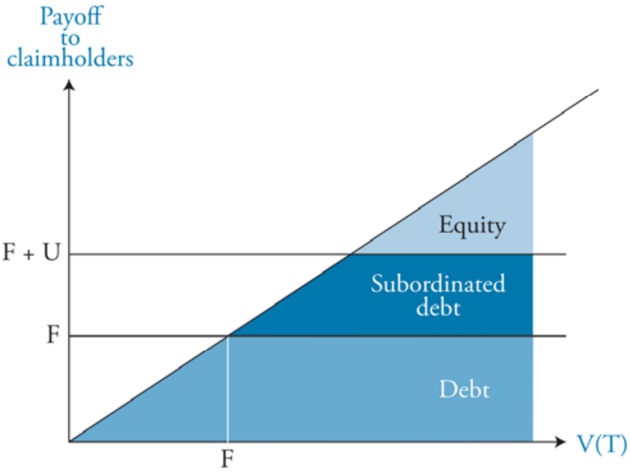



Figure 5 illustrates how subordinate debt values behave like equity when the firm has low values, as during periods of financial distress, and how they behave like senior debt when the firm is not in financial distress.

**Figure 5: Relationships for Capital Components for Low vs. High Firm Values**

| | *If Firm Value is Low Firm in Financial Distress* | | | *If Firm Value is High Firm Not in Financial Distress* | | |
|---|---|---|---|---|---|---|
| *Variable* | *Time to Maturity T* | *Firm Volatility σ* | *Annual Interest Rate r* | *Time to Maturity T* | *Firm Volatility σ* | *Annual Interest Rate r* |
| Senior debt | – | – | – | – | – | – |
| Subordinate debt | + | + | + | – | – | – |
| Equity | + | + | + | + | + | + |

## Interest Rate Dynamics

In the absence of credit risk, unanticipated changes in interest rates can affect the value of debt and the value of the firm. Increases in interest rates will decrease the value of debt because of pricing sensitivities of debt. Empirical evidence indicates that, on average, firm stock prices decline as interest rates rise. Therefore, to hedge debt, we need to account for the interactions between changing interest rates and firm value.

The **Vasicek model** allows for interest rates to revert to a long-run mean. The change in interest rates in the Vasicek model at time *t* is:

$$\Delta r_t = k(\theta - r_t)\Delta t + \sigma_r \varepsilon_t$$

where:
$k$ = speed that interest rate reverts to the long-run mean, $\theta$
$r_t$ = current interest rate
$\sigma_r$ = interest rate volatility
$\varepsilon_t$ = random error term

To value debt, Shimko, Tejima, and Van Deventer (1993)[1] developed a variation of the Merton model that included the correlation between firm value and changes in interest rates, $\rho_{(V,\Delta r)}$.

Figure 6 illustrates the relationships between interest rate dynamics of a low value firm (i.e., firm in financial distress) and the value of debt.

**Figure 6: Interest Rate Dynamics of Firm in Financial Distress**

| | $\rho_{(V,\Delta r)}$ | $k$ | $\sigma_r$ | $T$ |
|---|---|---|---|---|
| Value of debt | – | – | – | – |

The sensitivity of the value of debt to changes in interest rates is dependent on the volatility of interest rates. When interest rate volatility is high the debt values are less sensitive to changes in interest rates. Therefore, hedging against the adverse affect of changing interest rates is dependent on the parameters of the dynamic interest rate model.

## Application Difficulties

Application of the Merton model is complicated by the complexity of firms' capital structures. Most firms have a variety of debt instruments that mature at different times and have many different coupon rates (i.e., not just zero-coupons). In addition to the many different types of debt issues, the Merton model does not allow the firm value to jump. Since most defaults are surprises, the inability to have jumps in the firm value in the Merton model makes default too predictable.

Empirical research confirms the predictability of the Merton model. Jones, Mason, and Rosenfeld (1984)[2] report that a naïve model of predicting whether debt is riskless works better for investment grade bonds than the Merton model. However, the Merton model works better than the naïve model for debt below investment grade. Kim, Ramaswamy, and Sundaresan (1993)[3] report the Merton model's inability to predict credit spreads. The documented problems with the Merton model created the need for models to predict default more accurately (such as the KMV approach).

1. Shimko, David C., Naohiko Tejima, and Donald R. Van Deventer, 1993, "The Pricing of Risky Debt When Interest Rates Are Stochastic," *Journal of Fixed Income*, 3(2), 58–66.
2. Jones, Philip E., Scott P. Mason, and Eric Rosenfeld, 1984, "Contingent Claims Analysis of Corporate Capital Structures: An Empirical Investigation," *Journal of Finance*, 39(3), 611–625.
3. Kim, In Joon, Krishna Ramaswamy, and Suresh Sundaresan, 1993, "Does Default Risk in Coupons Affect the Valuation of Corporate Bonds?—A Contingent Claims Model," *Financial Management*, 22, 117–131.

## Using the Merton Model to Calculate PD and LGD

The simplest case for calculating probability of default assumes that the process for default is not correlated with the interest rate process or the recovery rate. The recovery rate is a fixed proportion of the principal that the debtholder receives in the event of default. The recovery rate is not dependent on time.

To find the value of debt, the probability of default and the recovery rate are required. If the debt is publicly traded, then the probability of default and the recovery rate can be estimated from the current price of debt; however, most debt instruments are not publicly traded.

In addition to the lack of public trading, there are four differences in measuring the risk of a debt portfolio that make estimating the probability of default and the loss due to default more challenging:

- If securities are illiquid, then the historical data is not reliable.
- The distribution of bond returns is not normal because the debtholder cannot receive more than the face amount plus the sum of the coupons.
- Debt is issued by creditors who do not have traded equity.
- Debt is not marked to market in contrast to traded securities. That is, a loss is recognized only if default occurs.

The Merton model for **probability of default** (PD) and **loss given default** (LGD) assumes that firm value is lognormally distributed with a constant volatility, and that the firm only has one liability, which is zero-coupon debt issue. The model also requires the expected return on the value of the firm, $\mu$. The Merton model for PD is:

$$\text{PD} = N\left(\frac{\ln(F) - \ln(V) - (\mu)(T-t) + 0.5\sigma^2(T-t)}{(\sigma)\sqrt{T-t}}\right)$$

where:
N = cumulative normal distribution
F = face value of the zero-coupon bond
V = value of the firm
T = maturity date on bond
$\sigma$ = volatility of firm value

Loss given default (LGD) is:

$$\text{LGD} = F \times (\text{PD}) - Ve^{\mu(T-t)} \times N\left(\frac{\ln(F) - \ln(V) - \mu(T-t) - 0.5\sigma^2(T-t)}{\sigma\sqrt{T-t}}\right)$$

**Example: Compute PD and LGD**

Suppose a firm with a value of $60 million has a bond outstanding with a face value of $50 million that matures in three years. The current interest rate is 6% and the volatility of the firm is 25%. What is the probability that the firm will default on its debt if the expected return on the firm, μ, is 15%? What is the expected loss given default?

**Answer:**

$$\text{PD} = \text{N}\left(\frac{\ln(50) - \ln(60) - (0.15)(3) + (0.5)(0.25)^2(3)}{(0.25)\sqrt{3}}\right) = \text{N}(-1.244) = 0.1069 = 10.69\%$$

$$\text{LGD} = 50(0.1069) - 60e^{0.15(3)}\text{N}\left(\frac{\ln(50) - \ln(60) - 0.15(3) - 0.5(0.25)^2(3)}{0.25\sqrt{3}}\right)$$

$$\begin{aligned}\text{LGD} &= 5.345 - (94.099)\text{N}(-1.677) = 5.345 - (94.099)(0.0468) = 5.345 - 4.404 \\ &= 0.941 = \$941{,}000\end{aligned}$$

Figure 7 illustrates the relationships between the inputs of the Merton model and the probability of default and then compares each relationship to loss given default.

**Figure 7: Relationships for PD and LGD Relative to Variables in the Merton Model**

| | *Value of Firm* | *Firm Value Volatility, σ* | *Expected Return, μ* | *Time to Maturity, T* | *Face Value of Debt, F* |
|---|---|---|---|---|---|
| Probability of default, PD | – | + | – | – | + |
| Loss given default, LGD | – | + | – | – | + |

## Credit Risk Portfolio Models

Portfolio credit risk models resolve some of the difficulties of measuring a portfolio's probability of default and the amount of loss associated with default when using the Merton model. The models also allow for the inclusion of additional securities and contracts, such as swaps. Therefore, instead of having only debtholders in the model, the model includes other obligors. Obligors include all parties who have a legal obligation to the firm.

Using various methodologies, credit risk portfolio models attempt to estimate a portfolio's credit value at risk. Credit VaR (also called **credit at risk** or **default VaR**) is defined much the same as VaR (a.k.a. market VaR); the minimum credit loss at a given significance over a given time period (or alternatively, the maximum credit loss for a given confidence level over a given time period).

Credit VaR differs from market VaR in that it measures losses that are due specifically to default risk and credit deterioration risk. Like market VaR, credit VaR is measured over a specified time period at a specified probability. There are two problems, however, when calculating credit VaR. First, calculating changes in credit quality over a 1-day period is difficult. Therefore, credit VaR is usually calculated over a year, where the potential change

in credit risk is more easily estimated. The second problem is that changes in credit risk are highly skewed and do not follow a normal distribution. The loss distribution of changes in credit quality for investment grade bonds closely resembles a lognormal distribution.

## CreditRisk+

CreditRisk+ measures the credit risk of a portfolio using a set of common risk factors for each obligor. Each obligor has its own sensitivity to each of the common risk factors. The model allows for only two outcomes (default or nondefault) for a loss of a fixed size. The probability of default for each obligor is dependent on the credit rating and the obligor's sensitivity to each of the risk factors. Conditional on the risk factors, the model assumes that defaults are uncorrelated across obligors.

Risk factors can only have positive values and are scaled to have a mean of one. The risk factors are assumed to follow a specific distribution, such as a gamma distribution. If an obligor has a risk factor greater than one, then the probability of default for firm *i* increases in proportion to the obligor's exposure. After the probability of default for each obligor is calculated, the loss distribution for the portfolio can be estimated and used to assess the credit risk of the portfolio.

## CreditMetrics

CreditMetrics is used for determining the credit value at risk (VaR) for large portfolios of debt claims.

Steps in calculating credit VaR using CreditMetrics:

*Step 1:* Determine rating class for debt claim.
*Step 2:* Use historical rating transition matrix to determine the probability that claim will migrate.
*Step 3:* Estimate the distribution of value for claim by computing the expected values for one year.
*Step 4:* Use the 1-year forward zero curves rates to get current price of zero-coupon bond for one year.
*Step 5:* Assume annual coupons to compute value of bond for each possible rating for next year.
*Step 6:* Compute the expected bond value $E(BV_p) = \sum_{i=1}^{N} p_i BV_i$. Then compute the credit value at risk (VaR) for a given confidence level.

where:
p = probability of migrating from a given rating
BV = the bond value plus coupon for a given rating

**Example: Compute VaR using CreditMetrics[4]**

Suppose your portfolio contains a senior unsecured bond issued by Triple-Bee, Inc. The bond with a credit rating of BBB matures in five years and pays a 6% coupon. If the recovery rate is 51.13%, what is the 1% credit VaR, given the following 1-year forward zero rates for the next four years and the 1-year transition probabilities of a bond with a BBB rating? Assume the bond's market price is $106.

**Figure 8: One-Year Forward Zero Curves Rate for Each Rating Class (%)**

| *Rating Class* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Bond Value Plus Coupon for Next Year* |
|---|---|---|---|---|---|
| AAA | 3.60 | 4.17 | 4.73 | 5.12 | 109.37 |
| AA | 3.65 | 4.22 | 4.78 | 5.17 | 109.19 |
| A | 3.72 | 4.32 | 4.93 | 5.32 | 108.66 |
| BBB | 4.10 | 4.67 | 5.25 | 5.63 | 107.55 |
| BB | 5.55 | 6.02 | 6.78 | 7.27 | 102.02 |
| B | 6.05 | 7.02 | 8.03 | 8.52 | 98.10 |
| C | 15.05 | 15.02 | 14.03 | 13.52 | 83.64 |

The bond value for next year is calculated by discounting the coupons and the principal amount by the appropriate forward rate. For example, the bond value for the BB rating class is calculated as:

$$6+\frac{6}{(1+0.0555)^1}+\frac{6}{(1+0.0602)^2}+\frac{6}{(1+0.0678)^3}+\frac{6+100}{(1+0.0727)^4}=102.02$$

**Figure 9: Estimation of Mean Bond Value Given the One-Year Probabilities of Migration from BBB and the Recovery Rate of 51.13% for the Triple-Bee Bond**

| *Year-End Rating Class* | *Probability of Migrating from BBB (%)* | *Cumulative Probability (%)* | *Bond Value Plus Coupon* | *(Probability) × (Bond Value Plus Coupon)* |
|---|---|---|---|---|
| AAA | 0.02 | 100.00 | 109.37 | 0.022 |
| AA | 0.33 | 99.98 | 109.19 | 0.360 |
| A | 5.95 | 99.65 | 108.66 | 6.465 |
| BBB | 86.93 | 93.70 | 107.55 | 93.493 |
| BB | 5.30 | 6.77 | 102.02 | 5.407 |
| B | 1.17 | 1.47 | 98.10 | 1.148 |
| C | 0.12 | 0.30 | 83.64 | 0.100 |
| Default | 0.18 | 0.18 | 51.13 | 0.092 |
| Expected bond value $E(BV_p)=\sum_{i=1}^{N} p_i BV_i$ | | | | 107.087 |

4. The data on which this example is based can be found in the CreditMetrics® Technical Manual, available on the RiskMetrics® Web site at www.riskmetrics.com.

**Answer:**

The cumulative probability column in Figure 9 estimates the first percentile. The expected bond value of 98.10 is at 1.47% in the cumulative distribution and is used as a proxy for the first percentile. Since credit VaR is the difference between the current bond price and the first percentile, the credit VaR for a bond with a current price of 106 is estimated to be $7.90 (= 106 – 98.10).

Correlations are important in a portfolio. If two bonds are independent, then the probability of both bonds migrating is the product of the individual events. If the bonds are not independent, then we need to know the migration correlations. The major complexity of CreditMetrics is estimating the joint migration of bonds in a portfolio. If the historical estimates for joint probabilities are used, then additional information is required. However, if stock returns are used to estimate the correlations between bond issues, the problem is solved. CreditMetrics recommends using a factor model where stock returns depend on country and industry indices as well as unsystematic risk.

## Moody's KMV Portfolio Manager

Previously, we discussed the KMV approach for estimating expected default probabilities. That approach is known as Moody's KMV Credit Monitor™. Another KMV model that is based on the Merton model, but is specifically designed for managing credit risk in a portfolio setting, is known as Moody's KMV Portfolio Manager™. KMV Credit Monitor provides data for Portfolio Manager.

The KMV model, a modified Merton model, calculates the **expected default frequencies** (EDFs) for each obligor. This modified model allows for more complicated capital structures (e.g., short-term debt, long-term debt, convertible debt, and equity). KMV solves for firm value and volatility.

The primary advantage of the KMV model is the use of current equity values in the model. This allows for the impact of a current event to immediately affect the probability of default. Ratings changes occur with a considerable lag. The use of equity values allows for probabilities of default to change continuously as equity values change. In the CreditMetrics approach, the value of the firm can change without any impact on the probability of default.

The KMV model computes the expected return from a variation of the capital asset pricing model (CAPM), which uses a factor model to simplify the correlation structure of firm returns. This provides for a direct estimation of the loss distribution without requiring the use of simulation to estimate the credit VaR of the credit portfolio.

## CreditPortfolioView

CreditPortfolioView models the transition matrices using macroeconomic or economic cycle data. This is its primary distinguishing feature. Macroeconomic variables are the key drivers of default rates, and CreditPortfolioView estimates an econometric model for an index that drives the default rates of an industrial sector. The model simulates paths of the index, which produces a distribution of portfolio losses to analyze. Usually the focus is on an aggregate default rate for an entire economy.

The user can select the inputs for the econometric model. Examples of often-used inputs are GDP growth, interest rates, and unemployment. In the United States and other countries, this data is readily available from public sources. The default rates per industry and country may not always be readily available in other countries, so proxies must be used.

The procedure can be summarized in four steps:

1. Measuring the autoregressive process of the macroeconomic variables.
2. Composing sector indices for the variables.
3. Estimating a default rate based on the value of that index.
4. Comparing the simulated values to historical values to determine the transition matrix to use.

The second and third parts of the procedure consist of simulating future possible realizations of the indices and then using an appropriate transformation (e.g., logistic transformation) on the simulations so they become a distribution of default rates. If the simulations indicate that the probability of default is above (below) the historical average, the user would conclude that the sector is in recession (expansion), and they would choose a recession (expansion) transition matrix.

## Limitations of the Credit Portfolio Models

Credit portfolio models have made improvements at estimating the probability of default; however, most models do not account for changes in:

- Interest rates.
- Credit spreads.
- Current economic conditions.

The state of the economy does affect probability of default for bonds. As the economy moves from an expansionary period to a recessionary period the distribution of defaults changes. In 1991 defaults were at a peak and then declined through the 1990s as the economy expanded. The correlations increase during a recession. Credit risk models that use historical correlations are not able to account for changing economic conditions.

## Credit Derivatives

### LO 21.4: Assess the credit risks of derivatives.

### LO 21.5: Describe a credit derivative, credit default swap, and total return swap.

A credit derivative is a contract with payoffs contingent on a specified credit event.

Credit derivatives are designed as hedging instruments for credit risks. Credit derivatives are usually traded over the counter (OTC) and not on exchanges.

Credit events include:

- Bankruptcy.
- Failure to pay.
- Restructuring.
- Repudiation.
- Moratorium.
- Obligation acceleration.
- Obligation default.

One of the simplest credit derivatives is a credit default put. A **credit default put** pays on a loss of debt due to default at the maturity of the debt claim, $T$.

**Example: Computing the payoffs from a credit default put**

Suppose a fixed income portfolio manager buys a bond issue with a face amount of \$100 million that matures in one year. The payoff of the risky bond is the same as a portfolio of owning a 1-year Treasury bill and a short position in a put written on the bond issuer's firm value with the exercise price equal to the face value of debt. To hedge the credit risk that the issuer of the debt will not pay the full amount, the debtholder can buy a credit default put on the value of the firm with an exercise price equal to the debt's face value. What is the payoff of holding a risky bond hedge with a credit default put, if the value of the risky firm's value is \$60 million?

**Answer:**

**Figure 10: Payoffs of Risky Bond Hedged With a Credit Default Put**

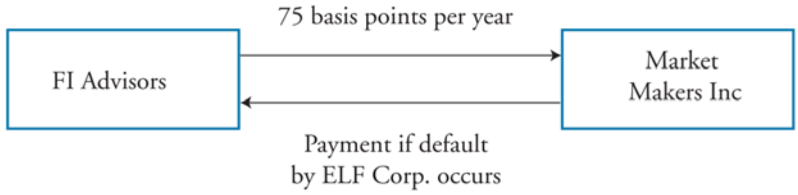
| | |
|---|---|
| Value of the firm, $V$ | 60 |
| Payoff of risk-free bond, $F$ | 100 |
| Short position in put –Max(F–V,0) | –40 |
| Risky debt is a risk-free bond + short put | 60 |
| Credit default put Max(F–V,0) | 40 |
| Hedged payoff | 100 |

A more complex and popular credit derivative is the **credit default swap** (CDS). A CDS is similar to a typical swap in that one party makes payments to another party. The purchaser of the CDS seeks credit protection and will make fixed payments to the seller of the CDS for the life of the swap, or until a credit event occurs. This differs from a typical interest rate swap where net payments are based on some fixed and floating rates of interest. The underlying "reference" in a CDS is whether a credit event takes place. If a credit event takes place, the buyer of the CDS will make a final "accrual" payment based on the amount of time elapsed since last payment. Then the swap is settled in either physical delivery of the reference obligation, or in cash.

If the terms of the swap agreement dictate settlement by physical delivery, the buyer of the CDS delivers the reference obligation to the seller of the swap and receives the par value. If the terms of the swap agreement are for cash delivery, dealers are surveyed a specified number of days following a credit event to determine a midpoint between bid and ask prices, called *Z*, which will then be used to calculate the cash payment as (100 – Z)% of the notional principal.

Suppose FI Advisors owns fixed income securities issued by ELF Corp. (the reference entity issued the reference obligation) with a par value of $200 million. FI Advisors would like to protect its position against credit risk by using a credit-default swap and is able to purchase this credit protection in a credit-default swap from Market Makers, Inc., for 75 basis points of a notional principal determined to be $200 million. The life of the CDS is five years, which will require FI Advisors to pay $1.5 million to Market Makers, Inc., every year. If ELF Corp. does not default, FI Advisors receives nothing from this agreement. If ELF Corp. does default, however, Market Makers, Inc., pays FI Advisors the notional principal of $200 million. The general CDS transaction can be seen in Figure 11.

**Figure 11: Example of Credit Default Swap**




**Total rate of return swaps** (TROR) are agreements to exchange the total return of a reference asset (i.e., a risky corporate bond) for a floating rate (LIBOR) plus a specified spread. The total return of the reference asset will include both capital gains (or losses) and any flows (coupons, interest, dividends) over the life of the swap.

The total-return payer payments would be similar to those of an investment in the underlying security in exchange for LIBOR plus the spread. If the payer owns the reference asset, a total return swap would allow the owner to transfer the credit risk of the asset to the receiver. If the payer does not own the reference asset, a total return swap's cash flows would be similar to those of taking a short position in the bond. If the value of the bond declines, the payer position gains. If the value of the bond increases, the payer position loses.

Conversely, the cash flows to the receiver can be viewed as the total return on the reference asset, which is a floating rate obligation. Although the payer counterparty retains ownership of the asset, the receiver is exposed to the capital gains (or losses) and the credit risk of the

asset. The spread above the floating rate the receiver is obligated to pay will depend on the credit risk of the reference asset, the creditworthiness of the receiver, and the correlation of credit quality between the reference asset issuer and the total return swap receiver.

## Derivatives With Credit Risks

A **vulnerable option** is an option with default risk. An option holder receives the promised payment only if the seller of the option is able to make the payment. Without the default risk, the holder of the option at expiration receives:

$$\text{Max}(S - X, 0)$$

where:
S = underlying asset's price at expiration
X = exercise price

The vulnerable option holder receives the promised payment only if the value of the counterparty firm, *V*, is greater than the required payment on the option. The payoff of the vulnerable option is:

$$\text{Max}[\text{Min}(V, S - X), 0]$$

The correlation between the value of the firm and the underlying asset value, $\rho_{(V,S)}$, is important in the valuations of the vulnerable option. If $\rho_{(V,S)}$ is strongly negative then vulnerable option has little value because firm value is low when vulnerable option payoff is to occur. If $\rho_{(V,S)}$ is strongly positive then there is no credit risk because firm value is high when the value of equity is high.

If the option has credit risk, then a derivative contract can be written to eliminate the credit risk. If the price of the vulnerable option can be estimated then the price of the credit derivative to insure the vulnerable option can be determined. The payoff of the option used to hedge the credit risk of a vulnerable option is:

$$\text{Max}(S - X, 0) - \text{Max}[\text{Min}(V, S - X), 0]$$

An alternative approach computes the probability of default and a recovery rate estimate if default occurs. The value of the option is the weighted average of the option without default. Following this approach, the value of a vulnerable option is:

$$\text{vulnerable option} = [(1 - PD) \times c] + (PD \times RR \times c)$$

where:
c = value of the option without default
PD = probability of default
RR = recovery rate

**Example: Compute the value of a vulnerable option**

Suppose a firm has a debt issue with a probability of default of 10% and a recovery rate of 40%. What is the value of the vulnerable option?

**Answer:**

Vulnerable option value = $(1 - 0.1)c + (0.1)(0.4)c = 0.90c + 0.04c = 0.94c$; therefore, the vulnerable option is worth 94% of the value of the option that is free of default risk.

## LO 21.6: Explain how to account for credit risk exposure in valuing a swap.

The credit risk in a swap can be reduced by requiring a margin or by netting the payments. Netting is a method where the payments are offset so that only one party needs to make a payment. The covenants of the swap agreement can affect the credit risk exposure. Suppose a counterparty that is due to receive a net payment is in default. If the swap agreement has a *full two-way payment covenant*, then the counterparty still receives the net payment. However, if the swap has a *limited two-way payment covenant*, the obligations are abolished if either party is in default. Valuing a swap can be simplified by considering a swap with only one payment.

Suppose there is only one payment to be made in a swap arrangement between Market Maker, Inc. and Risky Credit, Inc., which has no liabilities at the creation of the swap. The agreement provides for Risky Credit to receive a fixed amount, $F$, at maturity and to pay a variable amount, $S$, based on some index. The index could be based on an equity value or a floating rate. If the payments are netted, Market Maker will receive the difference between the variable payment and the fixed payment $(S - F)$, assuming there is no default risk such that Market Maker's payoffs are:

If $S < F$ then Market Maker pays $F - S$

If $S > F$ then Market Maker receives $S - F$

If Risky Credit's ability to pay is uncertain (subject to default risk), then the payment to be received from Risky Credit is the smaller of $(S - F)$ or the firm value of Risky Credit, $V$. When we consider the default risk of Risky Credit, the swap's payoff to Market Maker is:

$$(-)\text{Max}(F - S, 0) + \text{Max}[\text{Min}(S, V) - F, 0]$$

For Market Maker, the risk-free counterparty, the payoff of the swap is the same as a portfolio of a short position on a put option and a long position on a call. The put is written on an asset with a value of $S$ and an exercise price of $F$. The call option is written on the lower of the variable payment, $S$, or the value of the risky counterparty, $V$, with the exercise price of the fixed payment, $F$. At the initiation of the swap agreement, $F$ is selected so that the swap has no value.

The correlation between firm value, $V$, and the variable payment, $S$, is critical to the valuation of the swap. If the correlation declines, then there is no effect on the value of the put option, but the value of the option on the two risky assets declines.

## Key Concepts

### LO 21.1

Credit risk is the chance that a party will fail to make promised payments. The two important roles that credit risk plays in risk management programs are (1) assessing the potential of default by debt claimants and (2) assessing the potential of default by counterparties of derivatives contacts.

Given the assumptions of the Merton model, a levered firm's equity can be valued as a call option written on the value of the firm with the face value of debt as the exercise price and the time to the debt's maturity as the time to expiration. The value of equity is an increasing function of firm value, time to maturity of debt, interest rates, and volatility of the firm and a decreasing function of the face value of debt.

The value of debt, in the Merton model, is the difference between the firm value and the call option written on the value of the levered firm. The value of debt is an increasing function of firm value and the face value of debt and a decreasing function of the time to maturity of debt, interest rates, and the volatility of firm value.

A credit spread is the difference between the yield on a risky bond the yield on a risk-free bond given that the two instruments have the same maturity. As time to maturity increases, credit spreads tend to widen. A reduction in the risk of default will narrow credit spreads.

### LO 21.2

An extension of the Merton model provides for the pricing of subordinate debt. When a firm is experiencing financial distress (low firm values), the behavior of the values of subordinate debt are more similar to that of equity. However, if a firm is not experiencing financial distress (high firm values), the behavior of the values of subordinate debt resembles senior debt.

### LO 21.3

The sensitivity of the value of debt to changes in interest rates is dependent on the volatility of interest rates. When interest rate volatility is high, the debt values are less sensitive to changes in interest rates.

### LO 21.4

A credit derivative is a derivatives contract with payoffs contingent on a specified credit event. Credit events include the following: failure to make required payments, restructuring that harms the creditor, invocation of cross-default clause, and bankruptcy.

## LO 21.5

A credit default put is a credit derivative that pays on a loss of debt due to default at the maturity of the debt claim.

In a credit default swap (CDS), the party with the credit exposure from a debt claim will make fixed payments to a counterparty. The counterparty then agrees to pay the shortfall if the obligor is not able to meet the requirements of the debt contract (i.e., credit event). A credit event triggers the payment by the counterparty.

A total return swap involves swapping the total return from a debt obligation in exchange for a specified payment. The lending party who wants to hedge its credit risk exposure agrees to pay the interest payments and any decline in the market value of the debt instrument and receives a risk-free variable rate payment (usually based on LIBOR).

## LO 21.6

In a risky swap agreement, the correlation between a risky counterparty's firm value and the variable payment, is critical to the valuation of the swap. If the correlation declines, then there is no effect on the value of the put option, but the value of the option on the two risky assets declines.

## Concept Checkers

1. The role that credit risk plays in risk management programs includes assessing the potential default by:

   I. debt claimants.
   II. counterparties of a swap agreement.

   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

2. A non-dividend paying firm financed with 100% equity issues a zero-coupon bond with a principal amount of $50 million due in three years. What are the values of the different components of the firm's capital structure at the maturity date of the bond if the firm value at that time is $40 million?
   A. $50 million in debt and $10 million in equity.
   B. $10 million in debt and $30 million in equity.
   C. $50 million in debt and $40 million in equity.
   D. $40 million in debt and $0 in equity.

3. Suppose a firm has two debt issues outstanding. One is a senior debt issue that matures in three years with a principal amount of $100 million. The other is a subordinate debt issue that also matures in three years with a principal amount of $50 million. The annual interest rate is 5% and the volatility of the firm value is estimated to be 15%. If the volatility of the firm value declines in the Merton model, then which of the following statements is true?
   A. If the firm is experiencing financial distress (low firm value), then the value of senior debt will increase while the values of subordinate debt and equity will both decline.
   B. If the firm is not experiencing financial distress (high firm value), then the value of senior debt and subordinate debt and equity will increase.
   C. If the firm is experiencing financial distress (low firm value), then the value of senior debt and subordinate debt will increase while equity values will decline.
   D. If the firm is not experiencing financial distress (high firm value), then the value of senior debt will increase while the values of subordinate debt and equity will both decline.

4. Which of the following statements regarding the Merton model is true?
   A. A firm with numerous debt issues that mature at different times is easy to value with the Merton model.
   B. The Merton model assumes a lognormal distribution and constant variance for changes in firm value.
   C. The Merton model is able to predict default because it allows for default surprises (i.e., jumps).
   D. Empirical results indicate that the Merton model is able to predict default better than naïve models for investment grade bonds.

5. Which of the following is a characteristic of the KMV model?

   I. Each obligor has its own sensitivity to each of the common risk factors.
   II. It includes an estimate of correlation between firm values based on the correlation between observed equity values.

   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

## Concept Checker Answers

1. **C** Both statements are true. The two important roles that credit risk plays in risk management programs are (1) assessing the potential of default by debt claimants, and (2) assessing the potential of default by counterparties of derivatives contacts.

2. **D** The value of equity is the value of a call on the value of the firm with an exercise price equal to the face value of the zero-coupon bond, $S_T = \text{Max}(V_T - F, 0) = \text{Max}(40 - 50, 0) = 0$ (i.e., equity has no value). The value of debt is $D_T = F - \text{Max}(F - V_T, 0)$ or alternatively, $D_T = V_T - S_T$. Therefore, the value of debt is $40 - 0 = 40 = \$40$ million.

3. **A** When firms with subordinate debt are experiencing financial distress (low firm values), changes in the value of subordinate will react to changes in the model parameters in the same way as equity. Since equity is valued as a call option in the Merton model, a decline in volatility will reduce the value of equity (and subordinate debt). When firms with subordinate debt are not experiencing financial distress (high firm values), changes in the value of subordinate will react to changes in the model parameters in the same way as senior debt. Since senior debt is valued as the difference in firm value less equity valued as a call option in the Merton model, a decline in volatility will increase the value of senior debt (and subordinate debt).

4. **B** Most firms have a variety of debt instruments that mature at different times and have many different coupon rates (i.e., not just zero-coupons as assumed by the Merton model); therefore, Choice A is false. The Merton model assumes that the underlying asset follows a lognormal distribution with constant variance; therefore, Choice B is true. The Merton model does not allow the firm value to jump. Since most defaults are surprises, the inability to have jumps in the firm value in the Merton model makes default too predictable; therefore, Choice C is false. Jones, Mason, Rosenfeld (1984) report that a naïve model of predicting that debt is riskless works better for investment grade bonds than the Merton model. However, the Merton model works better than the naïve model for debt below investment grade; therefore, Choice D is false.

5. **B** Statement I is only true for CreditRisk+. Statement II is a characteristic and major advantage of the KMV model.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Credit and Counterparty Risk

Topic 22

## Exam Focus

In this topic, we provide an overview of various definitions related to credit risk. These definitions provide a foundation for understanding credit risk and will be important to know when modeling this risk. The main credit risk model discussed in this topic is the Merton model. We will discuss this model's assumptions and problems, and provide a detailed analysis of the model's parameters. For the exam, pay close attention to the calculations for probability of default, loss given default, and expected loss.

## Types of Credit Risk

### LO 22.1: Describe the credit risks associated with different types of securities.

Credit denotes an economic obligation to an outside entity that is not one of the owners of the firm's equity. **Credit risk** is either the risk of economic loss from default, or changes in credit events or credit ratings.

Types of credit risky securities include corporate and sovereign debt, credit derivatives, and structured credit products. Their interest rates include a credit spread above credit risk-free securities.

- **Corporate debt** includes fixed and floating rate bonds issued by corporations and bank loans, and technically represents the only credit risky security that can default.
- **Sovereign debt** is debt issued by central, state, provincial or local governments, or state-owned or controlled entities.
- **Credit derivatives** are contracts that transfer credit risk and whose payoffs depend on payoffs of other credit risky securities. The best known example of a credit derivative is a credit default swap (CDS).
- **Structured credit products** are bonds backed by pools of mortgages or loans or some other type of collateral. They are generally not defaultable, however, they are credit risky in the sense that if some of the underlying assets default, the value of these securities must be written down and the creditor must take a loss.

## Capital Structure

### LO 22.2: Differentiate between book and market values in a firm's capital structure.

Before we discuss credit risky securities and their valuations in greater detail, it is important to understand the firm's basic capital structure. In this LO, we will differentiate between a firm's book value and market value. **Book value** refers to the *accounting* balance sheet of the firm, where assets, debt, and equity are typically entered at book (historical) values. This differs from the *economic* balance sheet of the firm, where the components of the balance sheet are valued at market prices, or at some other value, including option pricing. The components of the economic balance sheet also include assets that are financed by debt and equity ($A_t = D_t + E_t$), where $A_t$ denotes the assets of the firm at current market prices, and $D_t$ and $E_t$ denote debt and equity at market prices. The **equity ratio**, or $E_t / A_t$, is the ratio of equity over assets, and the **leverage ratio**, or $A_t / E_t$, is the ratio of assets over equity.

Assets produce cash flows and profits. Debt is an obligation that finances assets and results in a liability that must be repaid in the future. Equity is the capital invested by the firm's owners, and represents a residual interest in the firm once all other creditors, including debt holders, are paid off. Equity, therefore, absorbs all losses before debt takes a loss. Equity owners are paid either in dividends or through reinvested capital in the firm.

## Debt Seniorities

Within the capital structure, different securities have different rights, including priority on payments and cash flows. **Debt seniority** is the order of repayment on obligations—typically debt or preferred shares—to creditors. Senior debt is repaid first, followed by repayment on junior debt.

Debt, especially corporate debt, can sometimes contain characteristics of both equity and debt securities. Three securities of note are preferred stock, convertible bonds, and payment in kind bonds.

**Preferred stock** (i.e., pref shares) are essentially hybrid securities that exhibit characteristics of both bonds and equity, with a priority in the event of default between common equity and bonds. Similar to bonds, they pay a fixed dividend and typically have no voting rights. Similar to common equity, they do not have a fixed maturity date and there is no legal obligation to pay dividends.

**Convertible bonds** are bonds that can be converted into a predetermined number of common shares during the bonds' life. As a result, it is often easier to think of these bonds as nonconvertible, plain vanilla bonds with a call option on the firm's equity. Mandatory convertible bonds must be converted to common shares at a future date (usually within three years). Given their relatively short term, the present value of coupons is generally not a large component of their value. Convertible pref shares can be convertible into a fixed number of common shares.

**Payment in kind** (PIK) **bonds** are bonds that pay interest in kind as additional par value bonds, rather than by paying interest in cash. This is essentially a deferred coupon where the

principal increases over time. PIK bonds are often issued as part of leveraged buyouts where the issuer is looking to defer cash payment as long as possible. PIK bonds are more junior to regular bonds as they increase the firm's indebtedness and hence its risk.

In addition to seniority, credit obligations can also be categorized based on security as either secured or unsecured. Unsecured obligations only have a general claim on assets in bankruptcy, while secured obligations have a claim on specific assets as collateral. This claim on collateral is called a *lien*, which allows a creditor to seize specific assets under a firm's bankruptcy, however, the proceeds can only be used to pay off the specific secured debt, and cannot be used to pay off other debt. Any amounts left over must be paid to the firm's owner. Liens are typically on real estate but can involve other securities including bonds, firm subsidiaries, or specific property.

Other terms associated with secured loans include haircut, recourse, and priority. A *haircut* in collateralized lending refers to a reduction in the collateral's value so that the full value of collateral is not being lent. Increases and reductions in haircuts is referred to as variation margin, while the initial amount of reduction is called initial haircut. *Recourse* in secured lending refers to the lender's right for claims against the borrower's assets beyond the value of the collateral if the collateral is insufficient to satisfy what the lender is owed. In a non-recourse or limited liability loan, the lender has no further claim beyond the collateral value. *Priority* refers to the order in which claims are satisfied under a borrower's bankruptcy. Secured debt has priority over unsecured debt, and within unsecured debt senior debt has priority over junior debt (debentures are examples of junior debt).

Asset classes outside of cash securities (e.g., bonds, notes, corporate debt) can also give rise to credit risk. These include derivatives on an underlying cash security (e.g., credit default swaps).

*Professor's Note: Credit default swaps (CDS) are not the focus of this topic, but will be discussed in detail later in this book.*

## Credit Contract Frictions

### LO 22.3: Describe common frictions that arise with the use of credit contracts.

Despite their advantages in mitigating credit risk, credit contracts suffer from a number of problems, including transaction costs, friction, and conflicts of interest issues.

**Asymmetric information** refers to different parties to a transaction having different information sets. For example, in credit transactions the borrower often has more or better information than the lender. Information asymmetries can be remedied through monitoring by the lender and adequate disclosures by the borrower.

**Principal-agent problems** arise when a principal hires an agent for specific duties, however, the agent has better information than the principal. Examples include *investment management relationships* (e.g., an investor as the principal hires an investment manager as an agent for trading, however, the manager's incentive is to maximize her own returns rather

than the investor's) and *delegated monitoring* (e.g., the interests of a bank's depositors or creditors as principals conflict with the interests of the bank's managers as agents).

**Risk shifting** occurs when risks and rewards are transferred from one group of market participants to another group holding different positions in the firm's capital structure. A classic conflict is between equity investors and lenders. Equity investors benefit from increasing risk to the firm's assets (e.g., from increased borrowing) as their investment is limited to their equity while their return potential is unlimited, however, bondholders' risk increases as their returns are fixed. Therefore, risk shifts from equity investors to bondholders. Institutions that are deemed "too-big-to-fail" can also cause risk shifting when risk is shifted from protected debt holders (e.g., secured or senior bondholders) to equity holders.

**Moral hazard** arises when buying insurance or some protection that reduces the incentive of the insured party to avoid the insured event. For moral hazard to arise, the insured party has the ability to mitigate the risk being insured, while the insurer cannot monitor the actions of the insured. A classic example is the insurance business. A homeowner insuring a home against fire may not purchase expensive smoke detectors, or a person with medical insurance may not look after his health as much as a person without insurance. In finance, firms that expect a bailout in bankruptcy may be prompted to take greater risks.

**Adverse selection** occurs when parties to a transaction have asymmetric information. For example, the entity selling an asset may know something adverse about the asset that the prospective buyer may not know, however, this negative information is not captured in the asset's price. In finance, a bank selling loans or securities in the markets may possess more information than the buyers.

**Externalities** are costs or benefits that occur when one party's actions cause others to absorb the cost or benefit. For example, a small group of borrowers in the short-term markets can drive up the cost for other borrowers. Asymmetric information arises as lenders have less information than borrowers which also creates externalities.

**Collective action problems** (i.e., *coordination failures*) occur when a group of individuals were to benefit collectively if they all took a course of action, but would not benefit if an individual alone took the same course of action. Examples of coordination failures include the Prisoner's Dilemma in game theory, or in finance where all creditors of a particular class cannot agree on terms and are all disadvantaged under bankruptcy.

## Default and Recovery

**LO 22.4: Explain the following concepts related to default and recovery: default events, probability of default, credit exposure, and loss given default.**

**Default** is the failure to pay a financial obligation. Default includes both *distressed exchanges* and *impairment*. Under a distressed exchange, creditors receive new securities with lower value than their original securities. From an accounting perspective, default occurs when the value of a firm's assets is less than the value of its liabilities (i.e., zero or negative equity). This may give rise to *impairment* where the asset values are written down. Note that impairment can occur without default. If a firm cannot satisfy its liabilities, it would be

forced into *bankruptcy*, which is a legal procedure in which the firm seeks protection from its creditors either via reorganization and restructuring (e.g., Chapter 11 bankruptcy) or via liquidation (e.g., Chapter 7 bankruptcy). In reality, firms may seek bankruptcy protection before their equity is fully diminished in order to allow the firm to continue its operations while preventing creditors from suing the firm.

The **probability of default** (PD) is the likelihood that a borrower will default within a specified time horizon. Probability of default is therefore the probability of a random default time $t^* \leq T$, where $T$ is the specified time horizon. PD is dependent on three factors:

1. Time $t$ from where we are viewing default (usually at present or $t = 0$, but could be a future date).

2. The time interval over which to measure default probabilities (usually beginning at $t = 0$ until time $T$ in the future, although the interval could also begin in the future).

3. A random variable time $t^*$ when default occurs.

**Exposure at default** (i.e., exposure) is the amount of money the lender can lose in the event of a borrower's default. Exposure for derivatives contracts depends on whether the contract is linear [e.g., futures which have zero net present value (NPV) at initiation] or nonlinear (e.g., options which almost always have a non-zero NPV). Exposure for swaps including interest rate swaps is the NPV of the swap.

**Loss given default** (LGD) is the amount of creditor loss in the event of a default. When default occurs, creditors typically do not lose the entire amount of their exposure. The fraction of exposure not lost (recovered) at default is *recovery*, an amount between 0% and 100%. Loss given default is therefore:

$$\text{exposure} = \text{recovery} + \text{LGD}$$

The *recovery amount* is the amount owed that creditors receive under bankruptcy, and depends on seniority, asset values, and business conditions. Recovery is generally expressed as the **recovery rate**, *RR,* where *RR* is a fraction between 0 and 1:

$$\text{RR} = \frac{\text{recovery}}{\text{exposure}} = 1 - \frac{\text{LGD}}{\text{exposure}}$$

Typical recovery rates for secured debt can exceed 75%, but are often close to 0% for junior unsecured debt. Both LGD and recovery are random variables that are not known in advance of a default. In addition, LGD may be correlated with the default probability, which may complicate the model. Nevertheless, many applications treat LGD as a known quantity.

## LO 22.5: Calculate expected loss from recovery rates, the loss given default, and the probability of default.

**Expected loss** (EL) is the expected value of the credit loss, and represents the portion of loss a creditor should provision for and treat as an expense item (e.g., on the income statement). If the only possible credit event is default, expected loss is equal to:

$$EL = PD \times (1 - RR) \times \text{exposure} = PD \times LGD$$

*Professor's Note: In this equation, LGD is in dollar terms, however, it could also be expressed as a percent (i.e., 1 – RR). On the exam, if LGD is given as a percent, EL = PD × LGD × exposure.*

If the credit event includes the possibility of both default and *credit migration* (e.g., potential changes in credit ratings), then EL is the probability-weighted sum of changes in value under the different scenarios.

It is important to note that both LGD and recovery are conditional expectations, that is, they are conditional on default occurring:

$$E[\text{loss} \mid \text{default}] = LGD = \frac{EL}{P[\text{default}]} = \frac{EL}{PD}$$

Consider an exposure of \$100,000 with a LGD of \$30,000 that is known with certainty. The recovery is therefore \$70,000, and the recovery rate, RR, is 70%. If the probability of default, PD, is 1%, the expected loss, EL, is 0.01 × \$30,000 = \$300.

So why would an investor invest in a security that has an expected loss? The simple answer is that the investor is looking to be compensated by a credit spread that would more than offset the expected loss. For risk-free bonds, an investor over one year would receive 1 + r, where *r* is the risk-free coupon. An investor would therefore expect to earn 1 + r + z on a risky bond, where *z* is the coupon spread that is expected to compensate for default. If default can only occur in one year just before a coupon payment, there are two possible payoffs on the risky bond:

1. The investor receives 1 + r + z, with probability 1 – PD.

2. The investor receives *RR*, with probability PD.

Because the future value of the risk-free bond is known with certainty to be 1 + r, the investor may prefer the risky bond as long as:

$$(1 - PD)(1 + r + z) + (PD)(RR) > 1 + r$$

where PD(1 – RR) is the expected loss, and (1 – PD)(1 – RR) is the unexpected loss at default.

## Credit vs. Market Risk Events

### LO 22.6: Differentiate between a credit risk event and a market risk event for marketable securities.

**Market risk** is the risk of economic losses from movements in market prices, including market price movements of credit-risky securities. **Credit risk** is the risk of borrower default on contractual obligations, but also includes other risks including credit downgrades. An issuer downgrade from A to BBB without a change in A spreads or interest rates is a pure *credit event*, while a widening spread between A and risk-free rates or a rise in risk-free rates is a pure *market event*. Note that there has historically been some ambiguity between credit and market risk. For example, a change in the perception of credit quality, even if it does not result in credit migration, may cause spreads to increase and give rise to credit risk (this specific credit risk is referred to as *mark-to-market risk*).

## Credit Assessment Techniques

### LO 22.7: Summarize credit assessment techniques such as credit ratings and rating migrations, internal ratings, and risk models.

A **credit rating** is an alphanumeric grade assigned by *credit rating agencies* that summarizes the creditworthiness of a particular security or entity. The most prominent credit rating agencies are Standard and Poor's (S&P), Moody's, and Fitch Ratings (Fitch), which have been granted special recognition by the Securities and Exchange Commission (SEC) in the U.S.

The ratings assigned by the credit rating agencies reflect the probability of default of entities and debt issues. AAA securities are considered virtually free of default risk, while a D rating signifies default. Investment grade securities range from AAA to BBB-, while non-investment (i.e., speculative) grade securities range from BB+ to C. Rating agencies also assess **rating migration**, or changes in ratings. Probability estimates are summarized in *transition matrices*, which show the estimated likelihood of a rating change for a company within a specified time period (usually one year). In other words, the matrix indicates the probability that a particular issuer will end the period with a different rating than what it initially began with. A typical 1-year ratings transition matrix by S&P can be seen in Figure 1.

**Figure 1: Transition Matrix**

| | *AAA* | *AA* | *A* | *BBB* | *BB* | *B* | *CCC/C* | *Default* |
|---|---|---|---|---|---|---|---|---|
| *AAA* | 91.42 | 7.92 | 0.51 | 0.09 | 0.06 | 0.00 | 0.00 | 0.00 |
| *AA* | 0.61 | 90.68 | 7.91 | 0.61 | 0.05 | 0.11 | 0.02 | 0.01 |
| *A* | 0.05 | 1.99 | 91.43 | 5.86 | 0.43 | 0.16 | 0.03 | 0.04 |
| *BBB* | 0.02 | 0.17 | 4.08 | 89.94 | 4.55 | 0.79 | 0.18 | 0.27 |
| *BB* | 0.04 | 0.05 | 0.27 | 5.79 | 83.61 | 8.06 | 0.99 | 1.20 |
| *B* | 0.00 | 0.06 | 0.22 | 0.35 | 6.21 | 82.49 | 4.76 | 5.91 |
| *CCC/C* | 0.00 | 0.00 | 0.32 | 0.48 | 1.45 | 12.63 | 54.71 | 30.41 |

The largest percentages within the matrix are shown by the diagonal figures starting from top left, which show the probability that securities would finish a year with unchanged ratings. For example, there is a 91.43% probability that a single A-rated security would maintain its A rating at the end of the year. Note that the probability of failure increases considerably as the starting credit rating falls. Also, default is considered a terminal state; that is, there is no transition *from* default.

It is important to understand that the ratings business gives rise to an inherent conflict of interest. Ratings agencies are compensated for ratings by bond issuers rather than by the sale of data to investors (this is called the issuer-pays model). This gives rise to a conflict between bond issuers, who benefit from receiving the highest ratings, and investors, who expect ratings to be based on an objective ratings methodology. Partly due to this conflict, many firms carry out their own internal assessment of credit quality through *internal models*, and may assign internal ratings to assist with credit-related or investment decisions.

**Credit risk models** are frequently used to assess credit risk of a single firm. The two main types of models are *reduced-form models* and *structural models*. Reduced-form models are technically not risk models which estimate default probabilities or LGD as outputs, but rather use these parameters as inputs to simulate default times. Structural models estimate credit risk from fundamental inputs primarily from balance sheet data.

## Counterparty Risk

**LO 22.8: Describe counterparty risk, compare counterparty risk to credit risk, and explain how counterparty risk can be mitigated.**

**Counterparty risk** is a type of credit risk that one of the parties to a transaction will not fulfill its obligations. In evaluating counterparty risk, two conditions must be satisfied: (1) the investment must be profitable, and (2) the counterparty must fulfill its obligation to the investor. However, counterparty risk is typically a two-way transaction with the line between borrower and lender blurred. This type of risk may arise under the following scenarios:

1. *OTC derivatives trading*. Each derivatives contract has two sides, and either side may be exposed to counterparty risk at any given time. In addition, OTC derivative trades are bilateral contracts between two private parties, which creates counterparty risk at any given time. In contrast, exchange-traded instruments, including options and futures, have significantly less counterparty risk given that a clearinghouse is at the center of each trade mitigating this risk.

2. *Brokerage relationships*. Historically it was assumed that only the broker in a brokerage relationship has counterparty risk, not the client. Following the subprime crisis, this assumption has changed following client losses from failed brokerages, while broker losses on client exposures remained rare.

**Netting** significantly reduces counterparty risk. Netting becomes particularly important as parties frequently trade multiple positions with each other, often buying and selling different quantities of the same contract within a day. Netting provides a gain to both parties as only the net amount of money needs to be paid, reducing counterparty risk. **Multilateral netting** is netting among multiple counterparties. Exposures under multilateral

netting are more difficult to calculate, however, the benefits are similar as under netting. Netting and settlement clearing are the primary reasons why clearinghouses were introduced in the U.S. in futures trading. In addition, counterparty exposures and netting are often governed through legal agreements including the ISDA Master Agreement.

It is important to distinguish counterparty risk from market risk. *Market risk* is the risk that the value of an underlying position will move against the trader due to adverse market factors, which may result in a negative NPV of the investment. *Counterparty risk* is the conditional risk that the NPV of the investment is positive, however, the counterparty fails to perform its obligations and therefore no profit is realized from the trade. To account for counterparty risk, the fair NPV of the position must be adjusted by a counterparty credit value adjustment (CVA).

One way to protect against counterparty risk in derivatives trading is **margin**. Margin is a form of collateral posted by both counterparties to cover potential losses from default. *Initial margin* is the amount of cash collateral posted by both sides at trade initiation. Initial margin tends to be small, particularly for most swap contracts, and the majority of margin arises from changes in the NPV of derivatives contracts which are posted daily as *variation margin*. Not all types of trades have small initial margin, however. Contracts including CDSs and CDS-related trades typically have large initial margin as these contracts require significant upfront payment in exchange for the counterparty selling protection.

Historically, derivatives dealers typically required their clients to post initial margin on both the long and short sides of a swap. It was also the dealer that considered making CVAs to OTC derivatives, rather than the client, to protect the dealer against potential client default. During the recent credit crisis, however, including the bankruptcy of Lehman Brothers, the assumptions of such one-sided protection proved incorrect. Clients suffered significant losses as a result of Lehman's default since Lehman held margin collateral, which then became part of the bankruptcy estate. This resulted in clients becoming unsecured general creditors of the Lehman bankruptcy estate for both the margin paid to Lehman and for their claims from the derivative contracts.

Counterparty risk can be mitigated by (1) accurately measuring exposures, (2) maintaining assessment of counterparty conditions, (3) dealing with a diverse group of counterparties, and (4) minimizing exposures to weaker counterparties.

Reducing exposures to a particular counterparty can be achieved by limiting the volume of OTC contracts traded with them, or by increasing the amount of collateral requirements against them. In the context of CDS trades, limiting the volume of trades to a counterparty is referred to as CDS compression. When there are multiple long and short CDS positions with a counterparty, compression reduces the set of CDS trades to a single net long or short position, which limits exposure to the counterparty. Some difficulties could arise, however, as contracts may not be identical regarding counterparty, premium, and maturity.

## Variations of Counterparty Risk

**Double default risk** is the risk that a counterparty that sold default protection on a third party will default at the same time as the third party. Therefore, double default risk is both a form of counterparty risk and correlation risk. One of the best-known historical examples

of double default risk was the case of American International Group (AIG). AIG is a well capitalized, highly rated U.S.-based insurance corporation that sold significant amounts of CDS protection on a variety of credit exposures. Given AIG's prominent market position, the protection buyers considered counterparty risk (i.e., the potential for AIG to default) to be minimal. To offset its exposures, AIG, through one of its subsidiaries, purchased a large quantity of highly rated mortgage-backed securities including collateralized debt obligations (CDOs). As the credit crisis unfolded, AIG was unable to meet its obligations under the CDS contracts it had written at the same time it suffered material impairments under the CDO contracts it held long.

**Custodial risk** refers to the risk of default by a custodian. Custodians provide *custodial services* by collecting cash flows including dividends and interest, and selling, lending, and transferring securities to be available for delivery. Custodians also maintain custody of securities in margin accounts in margin lending and prime brokerage relationships. This gives rise to custodial risk, as securities in margin accounts are not in the customer's name but are in *street name* so that they could be sold immediately to protect the lender against potential credit losses. This contrasts with securities in cash and nonmargin accounts, which are in *customer name* and are therefore not subject to custodial risk.

Brokers often provide custodial services in addition to credit intermediation services to clients. Collateral pledged by a client that is held by the broker can often be repledged by the broker as collateral to borrow money to fund its own operations. This is referred to as **rehypothecation**. Rehypothecation became a particular concern during the Lehman bankruptcy as the assets, including unpledged assets, of clients of one of Lehman's subsidiaries were not segregated and were therefore subject to rehypothecation. As a result these clients became creditors of Lehman during the bankruptcy proceedings as potentially unsecured lenders.

## The Merton Model

**LO 22.9: Describe the Merton Model, and use it to calculate the value of a firm, the values of a firm's debt and equity, and default probabilities.**

*Single-obligor credit risk models* are models of a single issuer of debt obligations. The model that is our primary focus is the **Merton model**, which relates the firm's balance sheet components to credit risk using the Black-Scholes-Merton option pricing model in order to value credit-risky corporate debt. The Merton model rests on a number of assumptions:

1. The market value of assets, $A_t$, and expected return, $\mu$, are related. Markets are in equilibrium and investors expect to earn a risk premium of $\mu - r$, where $r$ is the continuously compounded risk-free rate.

2. The basic function of $A_t = E_t + D_t$ describes the firm's balance sheet. Debt consists of a single zero-coupon bond with a nominal payment of $D$, maturing at time $T$. The notation $D$ refers to the notional value of debt, while $D_t$ and $E_t$ indicate the value of debt and equity at time $t$ (market values of debt and equity). The model also assumes that the firm can default only on the maturity date of the bond.

3. Equity consists of common shares only.

4. Debtholders have limited liability and have no recourse to any other assets once equity is eliminated.

5. Contracts are strictly enforced and debtholder obligations must be fully satisfied before equity owners can realize any value. Note that this assumption is somewhat unrealistic, as there are typically negotiations between debtholders and equity owners on how to distribute assets if a firm is undergoing reorganization.

6. Trading in markets occurs not only for the firm's equity and debt securities, but also for its assets. Traders can establish both long and short positions.

7. There are no cash flows prior to the maturity of the debt (including dividends).

Default occurs when the market value of the firm's assets is less than the face value of its obligations, or when $A_T < D$. $A_T - D$ is called the **distance to default**. Therefore, we can view the firm's debt and equity as European options on the value of the firm's assets with the same maturity as the firm's zero-coupon debt. Options can then be valued using the Black-Scholes-Merton option formula, although contrary to typical option pricing models, here we are looking to value credit risk.

As mentioned, the set of assumptions just outlined is not entirely realistic, including the assumption of an absence of negotiations between debtholders and equity owners during reorganization. In addition, it is unrealistic to assume that the value and volatility of the firm's assets would be known at any given time.

Now that we have outlined the set of assumptions, equity and debt values can be computed using option-pricing models as follows:

*Equity value of firm*: The value of assets, $A_t$, and the volatility of assets, $\sigma_A$, are seen as known quantities. Equity can be viewed as a call option on the firm's assets with an exercise price equal to $D$. At maturity date $T$, if the firm's assets are greater than its debt, the firm pays the value of debt. If the value of assets is less than the value of debt, equity is zero and the firm does not have sufficient resources to pay debt in full. The value of equity at maturity date $T$ can then be seen as:

$$E_T = \max(A_T - D, 0)$$

The notation $\tau = T - t$ represents the time to maturity, and the current value of equity, $E_t$, can then be valued using the Black-Scholes-Merton value of a $\tau$-year European call at a strike price of $D$.

*Market value of debt*: A similar formula can be set up for the value of debt. Here we value debt as a single risk-free bond maturing at value *D plus* a short put option on the firm's assets. The present value of the risk-free bond is $De^{-r\tau}$. The future value of debt is therefore:

$$D_T = D - \max(D - A_T, 0)$$

The present value of the bond adjusted for market risk can then be set up as:

$$D_t = De^{-r\tau} - (\text{European put value with strike at D})$$

*The firm's balance sheet*: The balance sheet equation of $A_t = E_t + D_t$ can be re-written as the value of a portfolio of the risk-free discount bond plus a long call and a short put option with strike prices of the nominal value of debt:

$$A_t = E_t + D_t = (\text{European call with strike at D}) + De^{-r\tau} - (\text{European put with strike at D})$$

*Leverage*: Leverage is simply the ratio of assets to equity.

*Probability of default (PD)*: The probability of default is the probability of exercising the put and call options. It is important, however, to differentiate between true/actuarial/physical probability of exercise and the risk-neutral probability.

The *actuarial (true or physical) PD* can be calculated using a stochastic process using the return on assets, $\mu$. PD can then be calculated using a lognormal distribution of the firm's assets with parameters $\mu$ and $\sigma_A$:

$$P[A_T < D] = \Phi\left[-\frac{\log\left(\frac{A_t}{D}\right) + (\mu - \frac{1}{2}\sigma_A^2)\tau}{\sigma_A\sqrt{\tau}}\right]$$

The risk-neutral PD uses a similar approach, with some minor variations in the formula:

$$\Phi\left[-\frac{\log\left(\frac{A_t}{D}\right) + (r - \frac{1}{2}\sigma_A^2)\tau}{\sigma_A\sqrt{\tau}}\right]$$

*Professor's Note: The symbol $\Phi$ represents a standard normal distribution function.*

*Yield to maturity and credit spread:* We can now also calculate the yield to maturity of debt and its credit spread. The yield to maturity of debt, $y_t$ is:

$$D_t e^{y_t \tau} = D$$

The equation can be re-arranged using the current market value of the debt:

$$[De^{-r\tau} - \text{European put option with strike at D}]e^{y_t\tau} = D$$

After taking logarithms, the formula becomes:

$$y_t = \frac{1}{\tau}\log\left[\left(1 - e^{-r\tau}\right)D + \text{European put option with strike at D}\right]$$

Finally, we can calculate the credit spread by subtracting the risk-free rate from both sides:

$$y_t - r = \frac{1}{\tau}\log\left[\left(1 - e^{-r\tau}\right)D + \text{European put option with strike at D}\right] - r$$

*Loss given default (LGD)*: The LGD depends on how much the value of the firm's debt exceeds the value of assets at maturity. In the Merton model, LGD is a random variable. Note that the actuarial expected default loss is not the current market value of the put option. Rather, the value of the put option is greater than the actuarial expected loss given the compensation to the put writer for taking on the risk and expected cost of default protection. The actuarial expected default losses can then be calculated as the future value of the actuarial default put option:

$$\text{expected default losses} = e^{r\tau}\,(\text{European put option with strike at D})$$

Dividing the actuarial expected default losses by the PD gives us the LGD:

$$\text{expected LGD} = \frac{\left[e^{r\tau}\left(\text{European put option with strike at D}\right)\right]}{\text{PD}}$$

Finally, we can compute the expected recovery rate as:

$$1 - \frac{1}{D}\left(\text{expected LGD}\right)$$

## LO 22.10: Explain the drawbacks of and assess possible improvements to the Merton Model.

As mentioned in the previous LO, the Merton model makes some unrealistic assumptions. Another drawback of the model is that it could result in low default probability values and high recovery rates for firms with high leverage. Firms with high leverage in reality would typically have higher default probabilities and lower recovery rates.

Despite its drawbacks, the Merton model has proved popular and has been adapted by several rating agencies in their proprietary models, including Moody's *KMV* and RiskMetrics' *CreditGrades* models. These models address the Merton model's two main shortcomings: (1) a firm's capital structure, especially its debt structure, is generally much more complex than the model implies, and (2) a firm's asset value and volatility is not directly observable in the market.

## Credit Factor Models

**LO 22.11: Describe credit factor models and evaluate an example of a single-factor model.**

Factor models relate the risk of credit loss to fundamental economic quantities. A simple version of a factor model is a single-factor model, which uses a random asset value from the Merton model as the value below which the firm defaults.

A single-factor model can be used to value a firm's asset return. With a horizon at the future date of $T = t + \tau$, asset return ($a_T$) can be calculated using a logarithmic formula:

$$a_T = \log\left(\frac{A_T}{A_t}\right)$$

As we've previously seen, default occurs when $A_T < D$. This is then identical to the event that:

$$a_T < \log\left(\frac{D}{A_t}\right) = \log\left(1 - \frac{E_t}{A_t}\right) \approx -\left(\frac{E_t}{A_t}\right)$$

Asset return under this model is a function of two random variables: (1) the return on a market factor *m* that denotes the correlation between default and the state of the economy, and (2) a shock $\varepsilon_i$ that captures idiosyncratic risk. Asset return and the variance of asset return can then be written as functions of the asset betas:

$$a_T = \beta m + \sqrt{1-\beta^2}\,\varepsilon$$

$$\text{Var}[a_T] = \beta^2 + 1 - \beta^2 = 1$$

The $\beta$ in the model above relates to asset beta rather than equity beta and captures the co-movement of the firm's returns with an unobservable market index.

Lastly, the single-factor model uses a default probability as an input (rather than an output as under the Merton model) that values the default threshold asset value (denoted as *k*) based on the *PD*-th quantile of $a_T$ using a standard normal distribution function. In summary, the single-factor model uses two parameters, $\beta$ and *k*, which can be estimated using balance sheet data and stock price information or firm ratings and transition matrices.

A practical example of the model would be to calculate the value of $\beta$ where systematic and idiosyncratic risk contribute equally to total credit risk, as measured by return variance. This would be at a $\beta$ value where:

$$\beta^2 = 1 - \beta^2 = \frac{1}{2} \Rightarrow \beta = \frac{1}{\sqrt{2}}$$

## Credit VaR

### LO 22.12: Define and calculate Credit VaR.

Credit VaR and the previous models for estimating credit risk statistics (e.g., unexpected loss) are related because they incorporate potential losses at a future date at a given probability. They differ, however, in two main respects. First, the time horizon for measuring credit risk is typically much longer than for market risk, and is generally around one year. As a result, *credit drift* for credit risk can be material and can also create issues that are usually not a concern with market risk, including the treatment of coupon payments and cost of funding positions. Second, extreme skewness is a material concern in credit risk. Extreme skewness arises given, in the rare event that default does occur, returns are very large and negative. Skewness results in a higher confidence interval for measuring credit VaR, usually at 99th and 99.9th percentiles.

Once a credit loss occurs, losses can be broken down into three components: expected loss, unexpected loss, and tail loss (loss beyond unexpected losses). *Expected loss* (EL) is the difference between the par value of a bond and its expected future value, factoring in default probability and recovery. *Unexpected loss* (UL) is a quantile of credit loss in excess of expected loss, defined either as standard deviation or the 99th or 99.9th percentile loss in excess of expected loss. **Credit VaR** is typically defined in terms of UL as the worst-case portfolio loss at a given confidence level over a specific holding period, minus the expected loss. This differs from market risk, where market risk VaR is defined in terms of profit and loss, that is, it compares a future value with a current value. Credit risk VaR compares two future values.

*Jump-to-default risk* is an estimate of the loss if a position were to immediately default. The jump-to-default value of $x$ units of a bond with a value of $p$ is $xpRR$, where $RR$ is the recovery rate. Note that jump-to-default risk can also be calculated without default probabilities as a form of stress testing, by looking at it as a worst-case scenario. Note that jump-to-default risk can be misleading for portfolios for two reasons. First, a portfolio with long and short positions that are offsetting will have artificially low jump-to-default values although portfolio risk is high. Second, a portfolio with only long positions will show artificially high jump-to-default values as it does not factor in diversification.

# Key Concepts

## LO 22.1

Credit is an economic obligation to an outside entity that is not one of the owners of the firm's equity. Credit risk is either the risk of economic loss from default, or changes in credit events or credit ratings. Credit risky securities include corporate and sovereign debt, credit derivatives, and structured credit products.

## LO 22.2

A firm's book value refers to the accounting balance sheet of the firm, whereas economic balance sheet of the firm refers to the components of the balance sheet valued at market prices. According to the basic balance sheet equation, assets equal debt plus equity. The equity ratio is equity over assets, and the leverage ratio is assets over equity.

## LO 22.3

Despite their advantages, credit contracts have a number of drawbacks, including asymmetric information, principal-agent problems, risk shifting, moral hazard problems, adverse selection, externalities, and collective action problems.

## LO 22.4

Default is the failure to pay a financial obligation and includes both distressed exchanges (creditors receive new securities with lower value than their original securities) and impairment (asset values are written down).

Probability of default is the likelihood that a borrower will default within a specified time horizon. Probability of default is dependent on the time from where we are viewing default, the time interval over which to measure default probabilities, and a random variable time when default occurs.

Exposure at default is the amount of money the lender can lose in the event of a borrower's default.

Loss given default (LGD) is the amount of creditor loss in the event of a default. LGD is essentially exposure less recovery. The recovery amount is the amount owed that creditors receive under bankruptcy, and depends on seniority, asset values, and business conditions.

## LO 22.5

Expected loss is the expected value of the credit loss, and is equal to the probability of default times LGD. Credit migration refers to the potential changes in credit ratings. Both LGD and recovery are conditional expectations.

## LO 22.6

Market risk is the risk of economic losses from movements in market prices. Credit risk is the risk of borrower default on contractual obligations, and includes other risks like credit downgrades.

## LO 22.7

A credit rating is an alphanumeric grade assigned by rating agencies that summarizes the creditworthiness of a particular security or entity.

Rating migration refers to a change in ratings. Probability estimates are summarized in transition matrices, which show the estimated likelihood of a rating change for a company within a specified time period. The ratings business suffers from conflicts of interest, including a conflict between bond issuers and investors.

## LO 22.8

Counterparty risk is a type of credit risk that one of the parties to a transaction will not fulfill its obligations. Two conditions must be met in evaluating counterparty risk: (1) the investment must be profitable, and (2) the counterparty must fulfill its obligation to the investor.

Credit risk is either the risk of economic loss from default, or changes in credit events or credit ratings. Counterparty risk is a type of credit risk that one of the parties to a transaction will not fulfill its obligations. Market risk is the risk that the value of an underlying position will move against the trader due to adverse market factors.

## LO 22.9

The Merton model is a single-obligor credit risk model that relates the firm's balance sheet components to credit risk using the Black-Scholes-Merton option pricing model in order to value credit-risky corporate debt. The Merton model rests on a number of simplifying and at times unrealistic assumptions.

## LO 22.10

The Merton model has been adapted by several rating agencies in their proprietary models, including Moody's KMV and RiskMetrics' CreditGrades models, which correct several of the Merton model's shortcomings.

## LO 22.11

Factor models relate the risk of credit loss to fundamental economic quantities. A single-factor model can be used to value a firm's asset return and default events.

### LO 22.12

Unexpected losses and credit VaR are related concepts since they both incorporate potential losses at a future date at a given probability, however, differ in that the time horizon for measuring credit risk is typically much longer than for market risk, and extreme skewness is a material concern in credit risk.

Losses following a credit loss can be broken down into expected loss, unexpected loss, and tail loss (loss beyond unexpected losses).

## Concept Checkers

1. CRS Capital has assets of $250,000 and debt of $150,000 on its balance sheet. Its equity and leverage ratios are closest to:

| | Equity ratio | Leverage ratio |
|---|---|---|
| A. | 0.4 | 1.7 |
| B. | 0.4 | 2.5 |
| C. | 0.7 | 1.7 |
| D. | 0.7 | 2.5 |

2. Following the aggressive risk-taking by one of the largest Australian hedge funds, the six month Australian LIBOR rate has increased from 3.5% to 3.8%. Which of the following economic terms best describes this scenario?
   A. Moral hazard.
   B. Adverse selection.
   C. Externalities.
   D. Risk shifting.

3. Jemis Fund Management Inc. (Jemis) is a mutual fund company that frequently trades interest rate swaps. One of the swaps currently outstanding has a net present value (NPV) of $2 million in Jemis' favor. According to Jemis, the $2 million represents its potential loss in the event of the counterparty's default. Which of the following terms best describes this amount?
   A. Exposure at default.
   B. Recovery.
   C. Expected loss.
   D. Loss given default.

4. A bank has an outstanding trade with one of its counterparties with an exposure of $500,000 and a recovery rate of 70%. The bank estimated that there is a 2% probability that the counterparty will default on its obligations. What is the bank's expected loss?
   A. $3,000.
   B. $7,000.
   C. $10,000.
   D. $150,000.

5. Which of the following statements regarding ratings transition matrices is least correct?
   A. Transition matrices assess rating migrations, that is, the probability that a company starting with a particular rating will be downgraded within the stated period.
   B. The diagonal elements in the transition matrix beginning at the top left show the probability of ending the year with an unchanged rating.
   C. Within a transition matrix, there is no transition from default to another rating.
   D. The probability of a rating migration is higher for lower rated companies.

## Concept Checker Answers

1. **B** The firm's equity is its assets less its debt, or \$250,000 – \$150,000 = \$100,000.

   The equity ratio is the ratio of equity to assets, or \$100,000 / \$250,000 = 0.4.

   The leverage ratio is the ratio of assets to equity, or \$250,000 / \$100,000 = 2.5.

2. **C** This scenario is an example of an *externality*. Externalities are costs or benefits that occur when one party's actions cause others to absorb the cost or benefit. In this case, the aggressive risk taking of one entity lead to an increase in short-term borrowing costs for all prudent borrowers in the Australian lending market.

3. **A** *Exposure at default (exposure)* is the *potential* amount lenders would lose in the event of a borrower's default. Exposure for interest rate swaps is the NPV of the swap. *Loss given default* (LGD) is the amount of creditor loss in the event that a default does occur, and is calculated as the exposure less recovery. The fraction of exposure not lost at default is *recovery*. *Expected loss* is the expected value of the credit loss, and is a factor of the probability of default and LGD.

4. **A** At a recovery rate of 70%, the recovery amount is \$500,000 × 0.70 = \$350,000.

   The loss given default (LGD) is \$500,000 – \$350,000 = \$150,000.

   Expected loss is (probability of default × LGD) = 0.02 × \$150,000 = \$3,000.

5. **A** Transition matrices assess the probability that a company's rating will remain *unchanged* at the end of a stated period. Rating migration measures the probability of a change in letter rating, however it encompasses both rating upgrades and downgrades.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Spread Risk and Default Intensity Models

Topic 23

## Exam Focus

Investors require a return for bearing credit risk, which is typically expressed relative to risk-free rates (e.g., yield spread, OAS, CDS spread). Default can be modeled with simple Bernoulli trials or more complicated intensity (hazard) models. For the exam, know the relationship between hazard rates, cumulative default probability, and conditional default probability. Also know that the credit spread is approximately equal to loss given default times probability of default.

## Spread Conventions

### LO 23.1: Compare the different ways of representing credit spreads.

### LO 23.2: Compute one credit spread given others when possible.

Informally, a credit spread represents the difference in yields between the security of interest (e.g., corporate bond) and a reference security (typically a higher rated instrument). Ideally, these two securities would have the same maturity, so the difference in yields represents the difference in risk premiums, not compensation for the time value of money. As intuitive and attractive as this definition is, unfortunately, it can be interpreted in many different ways. Figure 1 summarizes various spread measures.

**Figure 1: Various Spread Measures**

| *Spread Measure* | *Definition* |
|---|---|
| Yield spread | YTM risky bond – YTM benchmark government bond |
| i-spread | YTM risky bond – linearly interpolated YTM on benchmark government bond |
| *z*-spread | Basis points added to each spot rate on a benchmark curve |
| Asset-swap spread | Spread on floating leg of asset swap on a bond |
| CDS spread | Market premium of CDS of issuer bond |
| Option adjusted spread (OAS) | *z*-spread adjusted for optionality of embedded options.<br>*z*-spread = OAS if no option |
| Discount margin | Fixed spread above current LIBOR needed to price bond correctly |

The more common spread definitions (yield spread, i-spread, and *z*-spread) are demonstrated in the following examples.

*Example 1*: Assume the following information regarding XYZ Company and US Treasury yields.

| | *XYZ* | *US Treasury* |
|---|---|---|
| Coupon rate | 6% semi-annual coupon | 4% semi-annual coupon |
| Time to maturity | 20 years (7.25% YTM) | 20 years (4.0% YTM) |
| Yield curve | | 4.0% flat |

Based on the above information, yield spread = 7.25% – 4% = 3.25% (325 basis points)

*Example 2*: Assume the following information regarding XYZ Company and US Treasury yields.

| | *XYZ* | *US Treasury* |
|---|---|---|
| Coupon rate | 6% semi-annual coupon | 4% semi-annual coupon |
| Time to maturity | 19 years (7.25% YTM) | 20 years (4.0% YTM)<br>18 years (3.6% YTM) |
| Yield curve | | 4.0% flat |

Because the maturity of the XYZ bond does not match exactly with the maturity of the quoted Treasury bonds, the i-spread will be computed as:

i-spread = 7.25% – (4.0% + 3.6%) / 2 = 3.45%

*Example 3*: For this example, we consider the calculation of the *z*-spread in a continuous time framework. XYZ bond is trading at a 6% discount (94% of par) with an 8% semi-annual coupon and 10 years to maturity. Assume a flat swap curve at 10% and a spot rate of 9.6% compounded continuously for all maturities. The *z*-spread is calculated using the following expression:

$$0.94 = \left(\frac{0.08}{2}\right)\sum_{i=1}^{10\times 2} e^{-(0.096+z)0.5} + e^{-(0.096+z)10}$$

## Spread '01

### LO 23.3: Define and compute the Spread '01.

Recall the concept of DV01, the dollar value of a basis point, from the Part I curriculum. DV01 captures the dollar price change from a one basis point change in the current yield. A similar concept for credit spreads is known as DVCS (i.e., spread '01). Here, the potential change in the bond price is estimated from a one basis point change in the *z*-spread. Specifically, the *z*-spread is shocked 0.5 basis points up and 0.5 basis points down and the difference is computed.

For example, if the current *z*-spread is 207 bps and the bond is priced at $92, we could consider incremental 0.5 basis point changes to compute the spread '01. When the *z*-spread is increased by 0.5 basis points to 207.5 bps, the new bond price is $91.93 and when the *z*-spread tightens by 0.5 basis points to 206.5 bps, the bond price increases to $92.14. Hence, given a $100 par value, the spread '01 is: 92.14 – 91.93 = 0.21 dollars per basis point.

We can further study the comparative statistics of this result. Intuitively, the smaller the *z*-spread, the larger the effect on the bond price (i.e., the greater the credit spread sensitivity). This result is straightforward because the same one basis point change represents a larger shock relative to the current *z*-spread when the *z*-spread is low. Thus, the DVCS exhibits convexity.

## Binomial Distribution

### LO 23.4: Explain how default risk for a single company can be modeled as a Bernoulli trial.

A Bernoulli trial is an experiment or process where the outcome can take on only two values: success or failure (i.e., a binomial distribution). Success and failure are relative terms that denote that either the event happens ("success") or does not happen ("failure"). The obvious connection to our discussion is that a firm does or does not default during a particular time period. Let us define the relevant time period as $T_2 - T_1 = \tau$ where the firm will default with probability $\pi$ and remains solvent with probability $1 - \pi$. The mean and variance of a Bernoulli distribution is equal to $\pi$ and $\pi(1 - \pi)$, respectively.

An important property of the Bernoulli distribution is that each trial is conditionally independent. That is, the probability of default in the next period is independent of default in any previous period. Hence, if a firm has survived until the current period, the probability of default in the next period is the same as in its first year of existence. This memoryless property is exactly the same as studying a series of coin flips. For example, if you observed that a fair coin has landed on heads 10 consecutive flips, then the best guess for another heads on the 11th flip is still 50%.

Do not confuse this concept with the cumulative probability of default. Consider a firm with probability $\pi$ of default each period. The likelihood of surviving the next eight periods is $(1 - \pi)^8$. We can clearly see that as long as a firm has a positive probability of default, it will eventually default in a sufficiently long period of time.

## Exponential Distribution

### LO 23.5: Explain the relationship between exponential and Poisson distributions.

The exponential distribution is often used to model waiting times such as how long it takes an employee to serve a customer or the time it takes a company to default. The probability density function for this distribution is as follows:

$$f(x) = \frac{1}{\beta} \times e^{-x/\beta}, x \geq 0$$

In the above function, the scale parameter, $\beta$, is greater than zero and is the reciprocal of the "rate" parameter $\lambda$ (i.e., $\lambda = 1 / \beta$). The rate parameter measures the rate at which it will take an event to occur. In the context of waiting for a company to default, the rate parameter is known as the **hazard rate** and indicates the rate at which default will arrive.

As mentioned, the exponential distribution is able to assess the time it takes a company to default. However, what if we want to evaluate the total number of defaults over a specific time period? As it turns out, the number of defaults up to a certain time period, $N_t$, follows a Poisson distribution with a rate parameter equal to $t / \beta$.

A **Poisson random variable** *X* refers to the *number of successes per unit*, the parameter lambda ($\lambda$) refers to the average or *expected number of successes per unit*. The mathematical expression for the Poisson distribution for obtaining *X* successes, given that $\lambda$ successes are expected, is:

$$P(X = x) = \frac{\lambda^x e^{-\lambda}}{x!}$$

We can further examine the relationship between the exponential and Poisson distributions by considering the mean and variance of both distributions. The mean and variance of a Poisson distributed random variable is equal to $\lambda$ and, as it turns out, the mean of the exponential distribution is equal to $1 / \lambda$ and the variance is equal to $1 / \lambda^2$.

## Hazard Rates

### LO 23.6: Define the hazard rate and use it to define probability functions for default time and conditional default probabilities.

The hazard rate (i.e., default intensity) is represented by the (constant) parameter $\lambda$ and the probability of default over the next, small time interval, *dt*, is $\lambda dt$. Stated differently, the probability of default over $(t, t + dt) = \lambda dt$. It follows naturally that the probability of survival over the same time interval *dt* is $1 - \lambda dt$.

If the time of the default event is denoted $t^*$, the cumulative default time distribution *F*(*t*) represents the probability of default over (0, t):

$$P(t^* < t) = F(t) = 1 - e^{-\lambda t}$$

*Professor's Note: This equation calculates the cumulative probability of default (cumulative PD), which is an unconditional default probability.*

Similarly, the survival distribution is $P(t^* \geq t) = 1 - F(t) = e^{-\lambda t}$ and both survival and default probabilities sum to 1 at each point in time. In other words, if you have not defaulted by time *t*, then you have survived until this point. As *t* increases, the cumulative default probability approaches 1 and the survival probability approaches 0.

For completeness, we provide the marginal default probability (or default time density) function as the derivative of *F*(*t*) with respect to the variable *t*:

$$\lambda e^{-\lambda t}$$

It is evident that this quantity is always positive indicating that the probability of default increases over time related to the intensity parameter $\lambda$.

Previously, the exponential function was used to model the default probability over (0, t). If we examine the probability of default over $(t, t + \tau)$ given survival up to time *t*, the function is a conditional default probability. The instantaneous conditional default probability (for small $\tau$) is equal to $\lambda\tau$.

**Example: Computing default probabilities**

Given a hazard rate of 0.15, **compute** the one, two, and three-year cumulative default probabilities and conditional default probabilities.

**Answer:**

| *t* | *Cumulative PD* | *Survival Probability* | *PD(t, t+1)* | *Conditional PD Given Survival Until Time t* |
|---|---|---|---|---|
| 1 | $1 - e^{-0.15(1)} =$ 0.1393 | 1 – 0.1393 = 0.8607 | 0.1393 | |
| 2 | $1 - e^{-0.15(2)} =$ 0.2592 | 1 – 0.2592 = 0.7408 | 0.2592 – 0.1393 = 0.1199 | 0.1199 / 0.8607 = 0.1393 |
| 3 | $1 - e^{-0.15(3)} =$ 0.3624 | 1 – 0.3624 = 0.6376 | 0.3624 – 0.2592 = 0.1032 | 0.1032 / 0.7408 = 0.1393 |

Notice that the conditional probabilities in the far right column are constant.

## Risk-Neutral Hazard Rates

### LO 23.7: Calculate risk-neutral default rates from spreads.

In structural models, such as the Merton model, the default probabilities are based on specific pricing functions associated with the firm's assets and liabilities (in essence, structural models implicitly assume the modeler has as much information about the firm as the firm's managers). On the other hand, reduced form models will take the market price of liquid securities such as a credit default swap (CDS) as fairly priced and back out the market's aggregated expectations of default. To calculate risk-neutral default rates from spreads we are interested in working with reduced form models, which start with market observable spreads.

Let's start by comparing zero-coupon corporate bonds to maturity-matched default-free government bonds. Since the only cash flows occur at maturity, the current prices differ based on their yields. Specifically, the price of a default-free bond maturing in $\tau$ is:

$$p_\tau = e^{-r_\tau \tau}$$

where:
$r_\tau$ = continuous discount rate

Similarly, the price of a risky (corporate) bond with spread $z_\tau$ relative to the default-free bond with maturity $\tau$ is expressed as:

$$p_\tau^{corp} = e^{-(r_\tau + z_\tau)\tau} = p_\tau e^{-z_\tau \tau}$$

If there is no default, the price between the corporate and default-free bond converge to par over $\tau$. In case of default, creditors will recover a fraction of par, which is the recovery rate denoted as RR ($0 \leq RR \leq 1$).

As a simplifying assumption, suppose there will be no recovery of assets in default (i.e., RR = 0). Therefore, the corporate bond investor receives \$1 (par) if no default and \$0 if there is a default. On average, the expected value is:

$$e^{-\lambda_\tau^* \tau} \times 1 + \left(1 - e^{-\lambda_\tau^* \tau}\right) \times 0$$

On a present value basis discounting at risk-free rate generates:

$$e^{-r_\tau \tau}\left[e^{-\lambda_\tau^* \tau} \times 1 + \left(1 - e^{-\lambda_\tau^* \tau}\right) \times 0\right]$$

The final step is to equate this present value expression to the risky bond price and solve for $\lambda^*_\tau$:

$$e^{-(r_\tau + z_\tau)\tau} = e^{-r_\tau \tau}\left[e^{-\lambda_\tau^* \tau} \times 1 + \left(1 - e^{-\lambda_\tau^* \tau}\right) \times 0\right]$$

Solving for the risk-neutral hazard rate when the recover rate is zero shows that $\lambda^*_T = z_T$. Thus, the interpretation of this analysis is that the credit spread (*z*-spread) is the hazard rate.

When we introduce a positive recovery rate, the analysis changes slightly:

$$e^{-(r_T+z_T)\tau} = e^{-r_T\tau}\left[e^{-\lambda_T^*\tau}\times 1+\left(1-e^{-\lambda_T^*\tau}\right)\times RR\right]$$

After solving for the risk-neutral hazard rate, we end up with the following approximation:

$$\lambda_T^* \approx \frac{z_T}{1-RR}$$

Stated differently, the loss given default (1 – RR) times the default probability (hazard rate) is approximately equal to the credit spread (*z*-spread).

**Example: Computing hazard rate**

The three-year CDS on Bloomington Minerals and Mining has a spread of 400 basis points. The underlying nature of the business contains specialized equipment that has a limited resale potential. Thus, a credit analyst projects a 20% recovery rate in default. **Calculate** the hazard rate.

**Answer:**

$$\lambda_T^* \approx \frac{0.04}{1-0.2} = 0.05$$

## LO 23.8: Describe advantages of using the CDS market to estimate hazard rates.

The primary advantage of using CDS to estimate hazard rates is that CDS spreads are observable. Although we can create a model for the hazard rate (the probability of default in the next period conditional on surviving until the current period), the estimated value would inherently be a guess. Instead, we can draw on the logic of a reduced form model to use the observable, liquid CDS to infer the estimates of the hazard rate.

Our previous analysis on estimating hazard rates did not fully capture the complexities of the bond market. First, published estimates of default probabilities are insufficient as they are typically provided for a one-year horizon which may not match the duration of the analysis. Second, few corporations issue zero-coupon bonds. One can view commercial paper as *de facto* zero-coupon bonds but the issuing universe is restricted to large, highly-rated corporations. CDS can overcome these difficulties because liquid contracts exist for several maturities (e.g., 1, 3, 5, 7 and 10 years are common). Furthermore, a large number of liquid CDS curves are available (800 in U.S. markets, 1,200 in international markets) and the contracts are more liquid than the underlying cash bonds (i.e., narrower spreads and more volume).

## Hazard Rate Curves

### LO 23.9: Explain how a CDS spread can be used to derive a hazard rate curve.

Constructing the hazard rate curve uses a bootstrapping methodology not that different from bootstrapping a yield curve (moving from coupon yield curve to zero-coupon yield curve). The CDS spreads provide several discrete maturities to extract hazard rates. We know from casual observation that the CDS curves can take a variety of shapes so the constant hazard rate assumption from before is not likely to hold in practice. Technically, hazard rates are measured every instant in time so the CDS data will only provide a few observable data points and will require some form of interpolation or piecewise construction to complete the curve.

Intuitively, the hazard rate can vary over time. We can represent the time-varying hazard rate as $\lambda(t)$. When the hazard rate varies, the probability of default becomes:

$$\pi_t = 1 - e^{-\int_0^t \lambda(s)ds}$$

For the special case when the hazard rate is constant (i.e., $\lambda(t) = \lambda$ for all $t$), then the PD expression simplifies to $\pi_t = 1 - e^{-\lambda t}$. For practical purposes, the hazard rates used in default models are not constant but will not vary each instant in time either. Therefore, using CDS spreads is a reasonable compromise to accommodate changing hazard rates at discrete points in time.

Using the common CDS maturities (1, 3, 5, 7 and 10 years), the time-varying hazard rate function can be expressed in general form. In the following expression, five piecewise constant hazard rates are determined from observed CDS spreads.

$$\lambda(t) = \begin{Bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \end{Bmatrix} \quad \text{for} \quad \begin{Bmatrix} 0 < t \leq 1 \\ 1 < t \leq 3 \\ 3 < t \leq 5 \\ 5 < t \leq 7 \\ 7 < t \end{Bmatrix}$$

Subsequently, the integral in the above probability of default equation is determined as:

$$\int_0^t \lambda(s)ds = \begin{Bmatrix} \lambda_1 t \\ \lambda_1 + (t-1)\lambda_2 \\ \lambda_1 + 2\lambda_2 + (t-3)\lambda_3 \\ \lambda_1 + 2\lambda_2 + 2\lambda_3 + (t-5)\lambda_4 \\ \lambda_1 + 2\lambda_2 + 2\lambda_3 + 2\lambda_4 + (t-7)\lambda_5 \end{Bmatrix} \quad \text{for} \quad \begin{Bmatrix} 0 < t \leq 1 \\ 1 < t \leq 3 \\ 3 < t \leq 5 \\ 5 < t \leq 7 \\ 7 < t \end{Bmatrix}$$

Previously, the hazard rate was extracted from the default probability. This process relied on the simple idea that (PV of expected payments in default) = (PV of expected premiums paid). At CDS swap initiation no cash transfer takes place, but afterward if there is a change in credit quality, say, an improvement, the protection seller's position gains while the

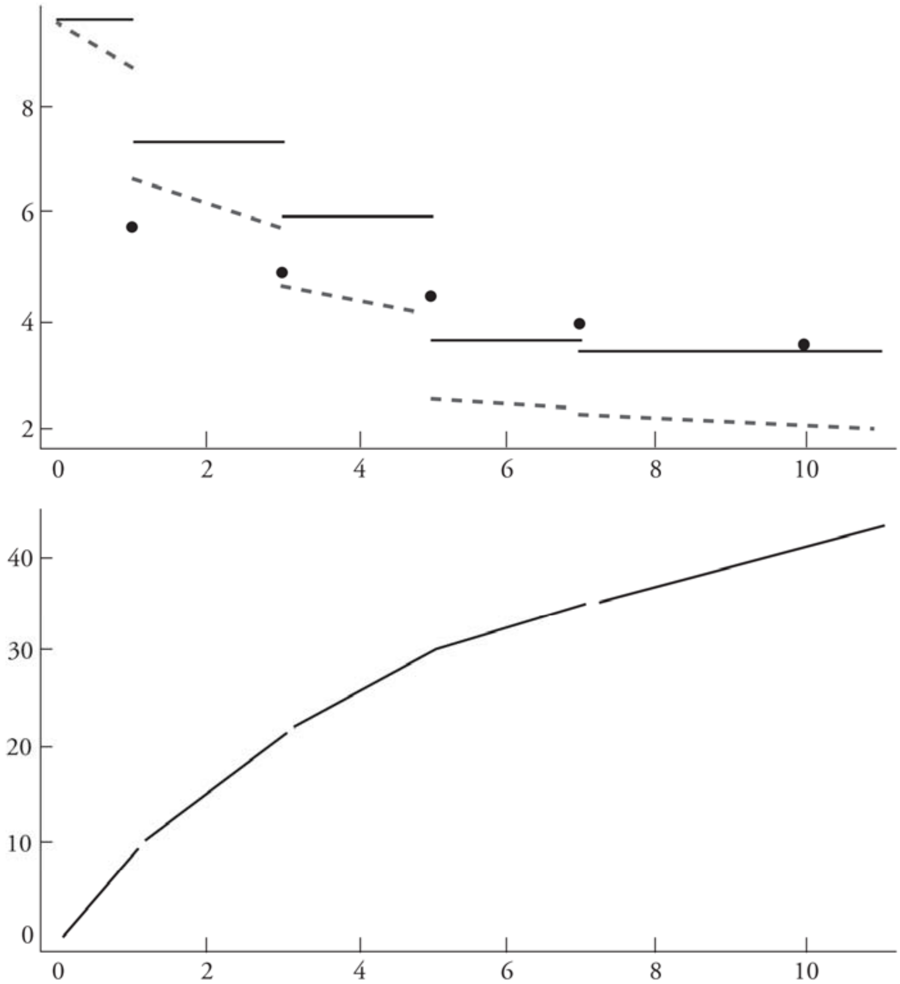
protection buyer's position loses (buyer is locked into paying too much for protection based on current conditions).

The fact that the CDS swap spread is observable allows for the inference of default probability for the 1-year maturity by equating (PV of expected payments in default) and (PV of expected premiums paid). Thus, given an assumed recovery rate (usually 40%), the probability of default and, hence, the hazard rate can be inferred for the first period (using the first piecewise portion of the earlier hazard function).

The bootstrapping procedure is then employed so that the hazard rate for the first period is used to infer the hazard rate for the second period from the piecewise function (using the observable information from the second CDS contract with a 3-year maturity, a recovery rate assumption, and the swap curve). Similarly, the hazard rate from the second period is an input to find the hazard in the third period, and so on. In this fashion, a graph can be constructed showing the CDS spreads, hazard rates, and default density.

CDS spreads (single points), the hazard rate curve (solid line), and default density (dashed line) are shown in the top graph in Figure 2. The default distribution, with a discontinuous slope when moving between hazard rates, is shown in the bottom graph in Figure 2.

**Figure 2: Default Curve Estimation**



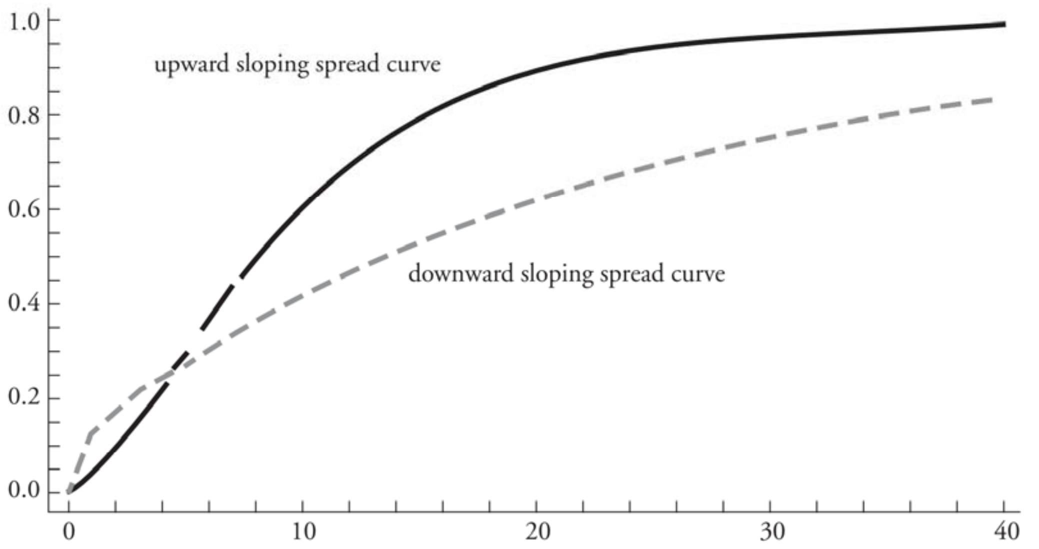
## LO 23.10: Explain how the default distribution is affected by the sloping of the spread curve.

In order to explain how the slope of the spread curve affects the default distribution, it is useful to think of the term structure of the CDS spread curves. As a benchmark, consider the impact of spreads that are constant for all maturities, that is, the market's expectations for default is constant. In this case, the spread curve would be flat implying the probability of defaulting in the near term is the same as defaulting in the long run.

The most common spread curve is upward sloping. Thus, the aggregate market forecast is that default is unlikely in the near term but increases with the forecast period. In contrast, spread curves, although unusual, may be downward sloping. This phenomenon would indicate relatively high expectations of short-term default (distress) but, if the firm can right itself, it will likely survive for a sufficiently long period of time. Therefore, the longer-term spreads are lower than the short-term spreads. This situation is similar to an inverted yield curve where short-term rates are extremely high (likely from high, short-term inflation) but are expected to moderate to a more natural, lower rate in the future.

On a relative basis, a downward-sloping spread curve (dotted line) has a steeper default distribution than an upward-sloping spread curve (solid line), because the cumulative default for a short horizon is higher. Similarly, for intermediate and longer terms, the cumulative default distribution of the downward-sloping spread curve is flatter as the probability of default decreases after surviving the short term.

**Figure 3: Default Distribution**



## Spread Risk

### LO 23.11: Define spread risk and its measurement using the mark-to-market and spread volatility.

Spread risk is the risk of loss from changes in the price of securities that have a positive probability of default. By extension, the spread risk for Treasury securities is zero for any maturity. Recall that at the initiation of a CDS, the parties have implicitly agreed on a fair swap spread so that the expected payments to both are equal. Thus, no cash trades hands up-front. Rather, the protection buyer is exposed to the narrowing of spreads if the creditworthiness improves as it has essentially agreed to now-above-market premiums. Naturally, a loss that is experienced by the protection buyer (i.e., fee payer) represents a gain to the protection seller (i.e., contingent payer). Similarly, the protection seller suffers when spreads widen as it has agreed to provide contingent compensation in case of default at a rate that is now viewed as too low.

To measure spread risk, the mark-to-market of a CDS and spread volatility can be used. The mark-to-market effect is computed by shocking the entire CDS curve up and down by 0.5 basis points (similar to spread '01). Note the slight difference from spread '01 where the *z*-spread, a single value, was shocked. Thus, the entire CDS curve moves up and down by a parallel amount. An alternative measure of spread risk is to compute the volatility (standard deviation) of spreads. The spread volatility can use historical data or can be forward-looking based on a subjective probability distribution. Not surprisingly, the spread volatility spiked extremely high during the recent financial crisis for many financial services firms.

# Key Concepts

## LO 23.1

A credit spread represents the difference in yields between the security of interest (e.g., corporate bond) and a reference security (typically a higher rated instrument). There are several different ways to capture the concept of spread including: yield spread, i-spread, *z*-spread, asset-swap spread, CDS spread, OAS, and discount margin.

## LO 23.2

The yield spread represents the difference between yield on the subject instrument and maturity-matched benchmark yield.

The i-spread (interpolated spread) uses linear interpolation when maturities do not match up precisely.

The CDS spread is the premium (percent of par) to protect against credit event.

The *z*-spread and OAS are computed rather than observed spreads. The *z*-spread is based on a hypothetical parallel shift of the benchmark curve to match the observed bond price. OAS is similar, but accommodates interest rate volatility and must be used for bonds with embedded options. *z*-spread = OAS when there are no embedded options.

## LO 23.3

Analogous to DV01, the spread '01 computes the price change from a one basis point change in the *z*-spread. Computationally, the *z*-spread is increased and decreased by 0.5 basis points and the difference in resulting prices is the spread '01. This measure exhibits convexity, so as the spread increases, the marginal change in the spread '01 decreases.

## LO 23.4

Bernoulli trials identify events as success (no default) and failure (insolvency) in each trial. The cumulative probability of default increases and, in the limit, all firms eventually default. The default process is memoryless – default in period ($T_i$, $T_{i+1}$) given no default until period $i$, is the same probability as default in the next period.

## LO 23.5

Modeling defaults can be done by modeling the time to the next event using an exponential distribution. The number of defaults up to a certain time period follows a Poisson distribution.

## LO 23.6

The hazard rate (or default intensity, $\lambda$) describes the likelihood of failure (default). When the hazard rate is constant, the arrival of the next default follows exponential distribution where cumulative default = $1 - e^{-\lambda t}$ and marginal probability of default is $\lambda e^{-\lambda t}$. This implies that the cumulative probability is increasing and all firms will eventually fail, and that the marginal probability of failure is decreasing. The conditional default probability computes the probability of default in the next period (distance of $\tau$) given survival until the current period and is calculated as $\lambda\tau$.

## LO 23.7

Intuitively, risk-neutral default rates can be inferred from spreads. Given a fixed recovery rate and observable spread, the probability of default (hazard rate) can be approximated as:

$$\lambda_{\tau}^{*} \approx \frac{z_{\tau}}{1 - RR}$$

## LO 23.8

CDS spreads are useful for estimating hazard rates because they are liquid, span multiple maturities and are standardized. These spreads provide more information about market expectations of default than typical default forecasts over the next period.

## LO 23.9

More complex hazard rate models assume the hazard rate is time-varying.

The probability of default is used to back out the hazard rate for the first period (assuming the hazard rate is time-varying). The process is repeated for the next maturity (via bootstrapping) to estimate the next probability of default and hazard rate. This piecewise process is continued for several observable CDS maturities.

A default distribution curve can be constructed from a hazard rate curve. The slope of the default distribution curve will be discontinuous to reflect the movement from one hazard rate to the next.

## LO 23.10

Spread curves may be upward sloping (typical shape) or downward sloping (short-term distress, but decreasing default risk if it can survive in the short term). Upward-sloping spread curves generate cumulative default distributions that are flatter in the short term but steeper afterward. Downward-sloping spread curves are steeper in the short term as the near probability of default is higher but then moderates to a flatter curve afterward.

## LO 23.11

Spread risk is the change in value of risky securities from changing spreads. Similar to DV01 and spread '01 calculations, the entire CDS curve is shocked up and down by 0.5 basis points to compute the CDS mark-to-market value. Spread risk can also be measured using the historical or forward-looking standard deviation of credit spreads.

## Concept Checkers

1. Which of the following statements is correct regarding spread measures?
   A. The yield spread and i-spread are equal if the benchmark yield curve is flat.
   B. The *z*-spread = OAS for callable bonds.
   C. The *z*-spread must be used for mortgage-backed securities (MBS).
   D. The CDS spread is used only with corporate bonds.

2. An analyst has noted that the default frequency in the pharmaceutical industry has been constant at 8% for an extended period of time. Based on this information, which of the following statements is most likely correct for a randomly selected firm following a Bernoulli distribution?

   I. The cumulative probability that a randomly selected firm in the pharmaceutical industry will default is constant.
   II. The probability that the firm survives for the next 6 years without default is approximately 60%.

   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

3. An analyst has gathered the following information about ABC Inc. and DEF Inc. The respective credit ratings are AA and BBB with 1-year CDS spreads of 200 and 300 basis points each. The associated probabilities of default based on published reports are 10% and 20%, respectively. Which of the following statements about the recovery rates is most likely correct?
   A. The market implied recovery rates are equal.
   B. The market implied recovery rate is higher for ABC.
   C. The market implied recovery rate is lower for ABC.
   D. The loss given default is higher for DEF.

4. Which of the following statements best explains the relationship between CDS spreads and hazard rates?
   A. Hazard rates are observable and can be used to infer credit spreads from backward induction.
   B. Credit spreads are observable and can be used to infer hazard rates from backward induction.
   C. Hazard rates are observable and can be used to infer credit spreads from bootstrapping.
   D. Credit spreads are observable and can be used to infer hazard rates from bootstrapping.

5. An analyst is studying the CDS spread curve for an established company. The 1-, 3- and 5-year spreads are 400 bps, 200 bps, and 150 bps, respectively. Which of the following interpretations of the data is most likely correct for the shape of the default distribution?

| | Default Distribution | Near-Term Slope |
|---|---|---|
| A. | Upward sloping | flat slope |
| B. | Downward sloping | steep slope |
| C. | Upward sloping | steep slope |
| D. | Downward sloping | flat slope |

## Concept Checker Answers

1. **A** If the yield curve is flat, there is no need for interpolation. Therefore, yield spread = i-spread. *z*-spread > OAS for callable bonds. OAS must be used for MBS. CDS measures the credit risk from any security with positive probability of default including sovereign and municipal bonds.

2. **B** Statement I is false because the cumulative probability of default increases (i.e., even the highest rated companies will eventually fail over a long enough period). Statement II is true since the probability the firm survives over the next 6 years without default is: $(1 - 0.08)^6 = 60.6\%$

3. **C** The approximation of credit spread = (1 – RR) × (PD). This implies:

   ABC: 200 bps = (1 – RR)(10%), so RR = 80%

   DEF: 300 bps = (1 – RR)(20%), so RR = 85%

   Thus, the market implied recovery rate is lower for ABC. Using loss given default terminology, LGD for ABC = 20% and LGD for DEF = 15%.

4. **D** Credit spreads are observable and, when used in conjunction with observed discount rates on swaps and the presumed recovery rate, the probability of default over the specific maturity can be inferred. The probability of default can, in turn, infer the hazard rate for the first period. Using the bootstrapped hazard rate from period 1, the second period hazard rate can be inferred using the same procedure with observable data corresponding to the longer maturity.

5. **C** The CDS spreads indicate a downward sloping spread curve. Note that the cumulative distribution of default is always increasing regardless of the slope of the spread curve. In addition, since the short-term probability of default is relatively high, the slope in the near term of the default distribution function is relatively steep.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Portfolio Credit Risk

Topic 24

## Exam Focus

In this topic, we discuss the role that default correlation plays in measuring the default risk for a credit portfolio. For the exam, be prepared to list drawbacks of using default correlation and explain the single-factor model approach under the assumption that defaults are independent and returns are normally distributed. Know how to calculate the mean and standard deviation of the default distribution under the single-factor model conditional approach for correlations of 0 and 1 and the unconditional approach for correlations between 0 and 1. Lastly, be able to explain how VaR is determined using the single-factor model and copula methodology based on simulated terminal values.

## Default Correlation for Credit Portfolios

### LO 24.1: Define default correlation for credit portfolios.

Risks to consider when analyzing credit portfolios include default probability, loss given default (LGD), probability of deteriorating credit ratings, spread risk, and risk of loss through restructuring in bankruptcy. **Default correlation** measures the probability of multiple defaults for a credit portfolio issued by multiple obligors.

Suppose there are two firms whose probabilities of default over the next time horizon $t$ are $\pi_1$ and $\pi_2$ for each firm, respectively. In addition, there is a joint probability that both firms will default over time horizon $t$ equal to $\pi_{12}$.

The default correlation for this simple two firm credit portfolio can be framed around the concept of Bernoulli-distributed random variables $x_i$, that have four possible outcomes over a specific time horizon $t$. Figure 1 illustrates the four possible random outcomes where 0 denotes the event of no default and 1 denotes default. The random variables for firm 1 and 2 are $x_1$ and $x_2$. The probabilities of the four random events (firm 1 defaults, firm 2 defaults, both firms default, and neither firm defaults) are illustrated in Figure 1.

**Figure 1: Default Probabilities for Two Firms**

| *Event* | $x_1$ | $x_2$ | $(x_1\ x_2)$ | *Default Probability* |
|---|---|---|---|---|
| Firm 1 Defaults | 1 | 0 | 0 | $\pi_1 - \pi_{12}$ |
| Firm 2 Defaults | 0 | 1 | 0 | $\pi_2 - \pi_{12}$ |
| Both Default | 1 | 1 | 1 | $\pi_{12}$ |
| No Default | 0 | 0 | 0 | $1 - \pi_1 - \pi_2 + \pi_{12}$ |

Thus, the probability that one of the firms defaults or both firms default equals: $\pi_1 + \pi_2 - \pi_{12}$. Since the probabilities of all four events must equal 1, the probability that no firm defaults is $1 - \pi_1 - \pi_2 + \pi_{12}$. The means of the two Bernoulli-distributed default processes are: $E[x_i] = \pi_i$, where $i$ equals 1 or 2. The expected value of joint default is simply the product of the two denoted as: $E[x_1x_2] = \pi_{12}$. The variances are computed as: $E[x_i]^2 - (E[x_i])^2 = \pi_i(1 - \pi_i)$ and the covariance is computed as: $E[x_1x_2] - E[x_1]E[x_2] = \pi_{12} - \pi_1\,\pi_2$.

Equation 1 defines the default correlation for a two firm credit portfolio as the covariance of firm 1 and 2 divided by the standard deviations of firm 1 and 2.

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}} \tag{1}$$

## Credit Portfolio Framework

### LO 24.2: Identify drawbacks in using the correlation-based credit portfolio framework.

A major drawback of using the default correlation-based credit portfolio framework is the number of required calculations. For example, to specify all possible outcome events in a three firm framework requires three individual firm default outcome probabilities, three two-default outcome probabilities, the three-default outcome probability, and the no default outcome probability. Thus, there are $2^n$ event outcomes with only $(n + 1) + [n(n - 1) / 2]$ conditions. If we have ten firms, there will be 1,024 event outcomes with 56 conditions. The number of pairwise correlations is equal to $n(n - 1)$. In modeling credit risk, the pairwise correlations are often set to a single, non-negative parameter.

In addition, certain characteristics of credit positions do not fit well in the default correlation credit portfolio model. Guarantees, revolving credit agreements, and other contingent liabilities have features similar to options that are not reflective of this simplistic framework. For example, credit default swap (CDS) basis trades may not be modeled simply by credit or market risk. Rather technical factors may play an important role as was evident in the subprime mortgage crisis where there was a lack of liquidity. Furthermore, convertible bonds have characteristics of credit and equity portfolios driven by market and credit risks.

Additional drawbacks in using the default correlation-based credit portfolio framework are related to the limited data for estimating defaults. Firm defaults are relatively rare events. Therefore, estimated correlations vary greatly depending on the data time horizon and industry. Most studies use an estimated correlation of 0.05. Thus, default correlations are small in magnitude, and the joint probability of two firms defaulting is even smaller.

## Credit VaR

### LO 24.3: Assess the impact of correlation on a credit portfolio and its Credit VaR.

The effects of default, default correlation, and loss given default are important determinants in measuring credit portfolio risk. A portfolio's credit value at risk (credit VaR) is defined as the quantile of the credit loss less the expected loss of the portfolio. Default correlation impacts the volatility and extreme quantiles of loss rather than the expected loss. Thus, default correlation affects a portfolio's credit VaR.

If default correlation is 1, then there are no credit diversification benefits, and the portfolio behaves as if there were just one credit position. A default correlation equal to 0 implies the portfolio is a binomial-distributed random variable because there is no correlation with other firms/credits.

**Example: Computing credit VAR (default correlation = 1, number of credits = n)**

Suppose there is a portfolio with a value of $1,000,000 that has *n* credits. Each of the credits has a default probability of π percent and a recovery rate of zero. This implies that in the event of default, the position has no value and is a total loss.

What is the extreme loss given default and credit VaR at the 95% confidence level if π is 2% and the default correlation is equal to 1?

**Answer:**

With the default correlation equal to 1, the portfolio will act as if there is only one credit. Viewing the portfolio as a binomial-distributed random variable, there are only two possible outcomes for a portfolio acting as one credit. Regardless of whether the number of credits in the portfolio, *n*, is 1, 20, or 1,000, it will still act as one credit when the correlation is 1.

The portfolio has a π percent probability of total loss and a (1 – π) percent probability of zero loss. Therefore, with a recovery rate of zero, the extreme loss given default is $1,000,000. The expected loss is equal to the portfolio value times π and is $20,000 in this example (0.02 × $1,000,000). There is a 98% probability that the loss will be 0, given the fact that π equals 2%. The credit VaR is defined as the quantile of the credit loss minus the expected loss of the portfolio. Therefore, at the 95% confidence level, the credit VaR is equal to –$20,000 (0 minus the expected loss of $20,000).

Note that if π was greater than (1 – confidence level), the credit VaR would have been calculated as $1,000,000 – $20,000 = $980,000.

**Example: Computing credit VAR (default correlation = 0, number of credits = 50)**

Again suppose there is a $1,000,000 portfolio with *n* credits that each have a default probability of *n* percent and a zero recovery rate. However, in this example the default correlation is 0, n = 50, and $\pi$ = 0.02. In addition, each credit is equally weighted and has a terminal value of $20,000 if there is no default. The number of defaults is binomially distributed with parameters of n = 50 and $\pi$ = 0.02. The 95th percentile of the number of defaults based on this distribution is 3. What is the credit VaR at the 95% confidence level based on these parameters?

**Answer:**

The expected loss in this case is also $20,000 ($1,000,000 × 0.02). If there are three defaults, the credit loss is $60,000 (3 × $20,000). The credit VaR at the 95% confidence level is $40,000 (calculated by taking the credit loss of $60,000 and subtracting the expected loss of $20,000).

The term "granular" refers to reducing the weight of each credit as a proportion of the total portfolio by increasing the number of credits. As a credit portfolio becomes more granular, the credit VaR decreases. However, when the default probability is low, the credit VaR is not impacted as much when the portfolio becomes more granular.

**Example: Computing credit VaR (default correlation = 0, number of credits = 1,000)**

Suppose there is a $1,000,000 portfolio with *n* credits that each have a default probability, $\pi$, equal to 2% and a zero recovery rate. The default correlation is 0 and n = 1,000. There is a probability of 28 defaults at the 95th percentile based on the binomial distribution with the parameters of n = 1,000 and $\pi$ = 0.02. What is the credit VaR at the 95% confidence level based on these parameters?

**Answer:**

The 95th percentile of the credit loss distribution is $28,000 [28 × ($1,000,000 / 1,000)] The expected loss in this case is $20,000 ($1,000,000 × 0.02). The credit VaR is then $8,000 ($28,000 – expected loss of $20,000).

Thus, as the credit portfolio becomes more granular, the credit VaR decreases. For very large credit portfolios with a large number of independent credit positions, the probability that the credit loss equals the expected loss eventually converges to 100%.

## Conditional Default Probabilities

**LO 24.4: Describe the use of a single factor model to measure portfolio credit risk, including the impact of correlation.**

The **single-factor model** is used to examine the impact of varying default correlations based on a credit position's beta. Each individual firm or credit, *i*, has a beta correlation, $\beta_i$, with the market, *m*. Firm *i*'s individual asset return is defined as:

$$a_i = \beta_i m + \sqrt{1-\beta_i^2}\,\varepsilon_i \tag{2}$$

where:
$\sqrt{1-\beta_i^2}$ = firm's standard deviation of idiosyncratic risk
$\varepsilon_i$ = firm's idiosyncratic shock

Assuming that each $\varepsilon_i$ is not correlated with other credits, each return on asset, $a_i$, is a standard normal variate. The correlation between pairs of individual asset returns between two firm's *i* and *j* is $\beta_i\beta_j$. The model assumes that firm *i* defaults if $a_i \leq k_i$, the logarithmic distance to the defaulted asset value that is measured by standard deviations.

An important property of the single-factor model is conditional independence. Conditional independence states that once asset returns for the market are realized, default risks are independent of each other. This is due to the assumption for the single-factor model that return and risk of assets are correlated only with the market factor. The property of conditional independence makes the single-factor model useful in estimating portfolio credit risk.

So, how can the single-factor model be used to measure default probabilities that are conditional on market movements or economic health? Suppose that the market factor, *m*, has a specific value of $\bar{m}$. Substituting this value $\bar{m}$ into Equation 2 and subtracting $\beta_i\bar{m}$ from both sides results in Equation 3. Default risk is measured by the distance to default, $a_i - \beta_i\bar{m}$. This distance to default either increases or decreases, and the only random parameter is the idiosyncratic shock, $\varepsilon_i$.

$$a_i - \beta_i\bar{m} = \sqrt{1-\beta_i^2}\,\varepsilon_i \tag{3}$$

As a result of this conditioning, the default distribution's mean shifts based on the specific market value for any beta, $\beta_i$, that is greater than zero. The default threshold, $k_i$, does not change, but the standard deviation of the default distribution is reduced from 1 to $\sqrt{1-\beta_i^2}$.

The unconditional default distribution is a standard normal distribution. However, the conditional distribution is a normal distribution with a mean of $\beta_i\bar{m}$ and a standard

deviation of $\sqrt{1-\beta_i^2}$. Specifying a specific value $\bar{m}$ for the market parameter, $m$, in the single-factor model results in the following implications:

1. The conditional probability of default will be greater or smaller than the unconditional probability of default as long as $\bar{m}$ or $\beta_i$ are not equal to zero. This reduces the default triggers or number of idiosyncratic shocks, $\varepsilon_i$, so that it is less than or equal to $k_i - \beta_i\bar{m}$. As the market factor goes from strong to weak economies, a smaller idiosyncratic shock will trigger default.

2. The conditional standard deviation $\sqrt{1-\beta_i^2}$ is less than the unconditional standard deviation of 1.

3. Individual asset returns, $a_i$, and idiosyncratic shocks, $\varepsilon_i$, are independent from other firms' shocks and returns.

## Conditional Default Distribution Variance

Suppose a firm has a beta, $\beta_i$, equal to 0.5 and a default threshold, $k_i$, equal to –2.33. The unconditional probability of default $\Phi(-2.33) = 0.01$. If the market return is –0.5, what is the conditional variance of the default distribution using the single-factor model?

*Professor's Note: Recall that the symbol $\Phi$ represents a standard normal distribution function.*

The conditional distribution is a normal distribution with a mean of $\beta_i\bar{m}$ and a conditional variance of $1-\beta_i^2$. For this example, the mean is $\beta_i\bar{m} = 0.5(-0.5) = -0.25$, and the conditional variance is $1 - 0.5^2 = 0.75$. The conditional standard deviation is then 0.866 (the square root of the variance of 0.75).

The conditional cumulative default probability function is stated as a function of $m$ as follows:

$$p(m) = \Phi\left(\frac{k_i - \beta_i\bar{m}}{\sqrt{1-\beta_i^2}}\right)$$

The mean is the new distance to default based on the realized market factor, $\beta_i\bar{m}$, and the standard deviation assumes conditional independence and is equivalent to $\sqrt{1-\beta_i^2}$. Thus, given a realized market factor, $\bar{m}$, the probability of default is based on the distance of the new default trigger of idiosyncratic shocks, $\varepsilon_i$, measured in standard deviations below its mean of zero.

*Professor's Note: For the exam, focus on how to calculate the parameters of the distribution (e.g., the mean and the standard deviation).*

If we assume that distribution parameters ($\beta$, $k$, and $\pi$) are equal for all firms, then the probability of a joint default for two firms can be defined as:

$$\Phi\binom{k}{k} = P[-\infty \le a \le k, -\infty \le a \le k]$$

This assumption also allows us to define the default correlation for any pair of firms as follows:

$$\rho = \frac{\Phi\begin{pmatrix} k \\ k \end{pmatrix} - \pi^2}{\pi(1-\pi)} \tag{4}$$

Although the derivation of this default correlation equation is not required for the exam, some candidates may wish to understand how Equation 1 (from LO 24.1) is used to derive Equation 4.

The single-factor model assumes the cumulative return distribution of any pair of credit positions *i* and *j* is distributed as a bivariate standard normal distribution with a correlation coefficient equal to $\beta_i\beta_j$. The cumulative distribution function for this pair, *i* and *j*, is $\Phi\begin{pmatrix} a_i \\ a_j \end{pmatrix}$. We are interested in the probability of a joint default that will occur in the extreme tail of the distributions. Thus, the probability that the realized value for credit *i*, $a_i$, is less than the default threshold, or critical value, $k_i$, and is denoted for the pair of credits *i* and *j* as:

$$\Phi\begin{pmatrix} k_i \\ k_j \end{pmatrix} = P\left[-\infty \le a_i \le k_i, -\infty \le a_j \le k_j\right]$$

In LO 24.1, Equation 1 defined the default correlation as the covariance of firm 1 and 2 divided by the standard deviations of firm 1 and 2 as follows:

$$\rho_{ij} = \frac{\pi_{ij} - \pi_i\pi_j}{\sqrt{\pi_i(1-\pi_i)}\sqrt{\pi_j(1-\pi_j)}}$$

Substituting $\Phi\begin{pmatrix} k_i \\ k_j \end{pmatrix}$ for $\pi_{ij}$ results in:

$$\rho_{ij} = \frac{\Phi\begin{pmatrix} k_i \\ k_j \end{pmatrix} - \pi_i\pi_j}{\sqrt{\pi_i(1-\pi_i)}\sqrt{\pi_j(1-\pi_j)}}$$

If we assume that parameters ($\beta$, $k$, and $\pi$) are equal for all firms, then the pairwise asset return correlation for any two firms must equal $\beta^2$ and the previous equation simplifies to Equation 4.

## Credit VaR with a Single-Factor Model

Previously, the loss distribution was estimated when the default correlation was either 0 or 1. In order to define the distribution of loss severity for values between 0 and 1, we need to determine the unconditional probability of default loss. Using the single-factor model framework, the unconditional probability of a default loss level is equal to the probability that the realized market return results in a default loss. In other words, the individual credit asset returns, $a_i$, are strictly a function of the market return and the asset return's correlation,

or $\beta_i$, with the market. The unconditional distribution used to calculate credit VaR is determined by the following steps:

1. The default loss level is assumed to be a random variable *X* with realized values of *x*. Under this framework, *x* is not simulated.

2. Given a loss level of *x*, the value for the market factor, *m*, is determined at the probability of the stated loss level. The relationship between the loss level and market factor return is equal to:

$$x(m) = p(m) = \Phi\left(\frac{k - \beta\bar{m}}{\sqrt{1-\beta^2}}\right)$$

The market factor return, $\bar{m}$, for a given loss level, $\bar{x}$, is determined based on the following relationship:

$$\Phi^{-1}(\bar{x}) = \left(\frac{k - \beta\bar{m}}{\sqrt{1-\beta^2}}\right)$$

3. The market factor is assumed to be standard normal, and therefore, a loss level of 0.01 (99% confidence level) is equal to a value of –2.33 based on the standard normal distribution.

4. These steps are repeated for each individual credit to determine the loss probability distribution.

**Example: Realized market value**

Suppose a credit position has a correlation to the market factor of 0.25. What is the realized market value used to compute the probability of reaching a default threshold at the 99% confidence level?

**Answer:**

At the 99% confidence level, the default loss level has a default probability, $\pi$, of 0.01. A default loss level of 0.01 corresponds to –2.33 on the standard normal distribution. The relationship between the default loss level and the given market return, $\bar{m}$, is defined by:

$$p(\bar{m}) = 0.01 = \Phi\left(\frac{k - \beta\bar{m}}{\sqrt{1-\beta^2}}\right)$$

This is approximately equal to the probability of obtaining a realized market return of –2.33 as follows:

$$\Phi^{-1}(0.01) \approx -2.33 = \left(\frac{k - \beta\bar{m}}{\sqrt{1-\beta^2}}\right)$$

The realized market value is computed as follows:

$$-2.33 = \frac{-2.33 - (0.25)\bar{m}}{\sqrt{1 - 0.25^2}}$$
$$-2.33(0.9682) = -2.33 - (0.25)\bar{m}$$
$$-2.256 + 2.33 = -(0.25)\bar{m}$$
$$0.074 = -(0.25)\bar{m}$$
$$-0.296 = \bar{m}$$

The probability that the default threshold is reached is the same probability that the realized market return is –0.296 or lower.

The parameters play an important role in determining the unconditional loss distribution. The probability of default, $\pi$, determines the unconditional expected default value for the credit portfolio. The credit position's correlation to the market, $\beta$, determines the dispersion of the defaults based on the range of the market factor.

## Credit VaR with Copulas

**LO 24.5: Describe how Credit VaR can be calculated using a simulation of joint defaults with a copula.**

Copulas provide a mathematical approach for determining how defaults are correlated with one another using simulated results. The following four steps are used to compute a credit VaR under the copula methodology:

1. Define the copula function.
2. Simulate default times.
3. Obtain market values and profit and loss data for each scenario using the simulated default times.
4. Compute portfolio distribution statistics by adding the simulated terminal value results.

**Example: Computing credit VaR with a copula**

Suppose there is a credit portfolio with two loans (rated CCC and BB) that each has a notional value of \$1,000,000. Figure 2 illustrates four possible event outcomes over a default time horizon of one year for this credit portfolio. The four event outcomes are only the BB rated loan defaults, only the CCC rated loan defaults, both loans default, or no loans default.

**Figure 2: Event outcomes for a two credit portfolio**

| *Event* | *Default Time* |
|---|---|
| BB Default | $(\tau_{BB,i} \leq 1, \tau_{CCC,i} > 1)$ |
| CCC Default | $(\tau_{BB,i} > 1, \tau_{CCC,i} \leq 1)$ |
| Both Default | $(\tau_{BB,i} \leq 1, \tau_{CCC,i} \leq 1)$ |
| No Default | $(\tau_{BB,i} > 1, \tau_{CCC,i} > 1)$ |

How can credit VaR be estimated for this portfolio assuming a correlation of 0.25?

**Answer:**

The copula approach to estimating credit VaR is applied using the following steps:

1. The first step is to simulate 1,000 values using a copula function. The most common copula used to calculate credit VaR is the normal copula.

2. The 2,000 simulated values (1,000 pair simulations results in 2,000 values) are then mapped to their standard univariate normal quantile which results in 1,000 pairs of probability values.

3. The first and second elements of each probability pair are mapped to the BB and CCC default times, respectively.

4. A terminal value is assigned to each loan for each simulation. The values are added up for the two loans, and the sum of the no-default event value is subtracted to determine the loss. Figure 3 summarizes the sum of the terminal values and losses for 1,000 simulations.

**Figure 3: Event outcomes for a two credit portfolio**

| *Event* | *Default Time* | *Terminal Value* | *Loss* |
|---|---|---|---|
| BB Default | $(\tau_{BB,i} \leq 1, \tau_{CCC,i} > 1)$ | 1,480,000 | 710,000 |
| CCC Default | $(\tau_{BB,i} > 1, \tau_{CCC,i} \leq 1)$ | 1,410,000 | 780,000 |
| Both Default | $(\tau_{BB,i} \leq 1, \tau_{CCC,i} \leq 1)$ | 700,000 | 1,490,000 |
| No Default | $(\tau_{BB,i} > 1, \tau_{CCC,i} > 1)$ | 2,190,000 | 0 |

The loss level sums from the simulation are then used to determine the credit VaR based on the simulated distribution. In this simulation, the 99% confidence level corresponds to the $1,490,000 loss where both loans default. The 95% confidence level corresponds to the $780,000 value because the lower 5% of the simulated values resulted in defaults with a total loss of $780,000.

# Key Concepts

## LO 24.1

The default correlation for a two credit portfolio assuming the outcomes are Bernoulli-distributed random variables is:

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$$

## LO 24.2

Drawbacks of using the default correlation-based credit portfolio framework are the number of required calculations ($2^n$ event outcomes with (n + 1) + [n(n – 1) / 2] conditions), certain characteristics of credit positions do not fit well in the default correlation credit portfolio model, and the limited data for estimating defaults due to the fact that firm defaults are relatively rare events.

## LO 24.3

A portfolio's credit value at risk is defined as the quantile of the credit loss less the expected loss of the portfolio. A default correlation equal to 0 implies the portfolio is a binomially distributed random variable. As a credit portfolio becomes more granular, the credit VaR decreases.

## LO 24.4

In the single-factor model, firm *i*'s individual asset return is defined as:
$a_i = \beta_i m + \sqrt{1-\beta_i^2}\,\varepsilon_i$ where $\sqrt{1-\beta_i^2}$ is the firm's standard deviation of idiosyncratic risk, and $\varepsilon_i$ is the firm's idiosyncratic shock. The model assumes that firm *i* defaults if $a_i \leq k_i$.

The single-factor model framework states that the unconditional probability of a default loss level is equal to the probability that the realized market return results in a default loss. The market factor is assumed to be standard normal. The credit position's correlation to the market, $\beta$, determines the dispersion of the defaults based on the range of the market factor.

## LO 24.5

A credit VaR under the copula methodology is computed by: defining the copula function, simulating default times, obtaining market values and profit and loss data for each scenario using the simulated default times, and computing the portfolio distribution statistics by adding the simulated terminal value results.

## Concept Checkers

1. Which of the following equations best defines the default correlation for a two firm credit portfolio?
   A. $\rho_{12} = \dfrac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$
   B. $\rho_{12} = \dfrac{\pi_{12}}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$
   C. $\rho_{12} = \dfrac{\pi_{12}}{\sqrt{(1-\pi_1)}\sqrt{(1-\pi_2)}}$
   D. $\rho_{12} = \dfrac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1}\sqrt{\pi_2}}$

2. Suppose a portfolio manager is using a default correlation framework for measuring credit portfolio risk. How many unique event outcomes are there for a credit portfolio with eight different firms?
   A. 10.
   B. 56.
   C. 256.
   D. 517.

3. Suppose a portfolio has a notional value of $1,000,000 with 20 credit positions. Each of the credits has a default probability of 2% and a recovery rate of zero. Each credit position in the portfolio is an obligation from the same obligor, and therefore, the credit portfolio has a default correlation equal to 1. What is the credit value at risk at the 99% confidence level for this credit portfolio?
   A. $0.
   B. $1,000.
   C. $20,000.
   D. $980,000.

4. A portfolio manager uses the single-factor model to estimate default risk. What is the mean and standard deviation for the conditional distribution when a specific realized market value $\bar{m}$ is used?
   A. The mean and standard deviation are equivalent in the standard normal distribution.
   B. The mean is $\beta_i \bar{m}$ and the standard deviation is $\sqrt{1-\beta_i^2}$ .
   C. The mean is $\bar{m}$ and the standard deviation is $\beta_i$.
   D. The mean is $\bar{m}$ and the standard deviation is 1.

5. Suppose a credit position has a correlation to the market factor of 0.5. What is the realized market value that is used to compute the probability of reaching a default threshold at the 99% confidence level?
   A. –0.2500.
   B. –0.4356.
   C. –0.5825.
   D. –0.6243.

## Concept Checker Answers

1. **A** The default correlation for a two firm credit portfolio is defined as:

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$$

2. **C** There are 256 event outcomes for a credit portfolio with eight different firms calculated as: $2^8 = 256$.

3. **D** With the default correlation equal to 1, the portfolio will act as if there is only one credit. Viewing the portfolio as a binomial distributed random variable, there are only two possible outcomes for a portfolio acting as one credit. The portfolio has a 2% probability of total loss and a 98% probability of zero loss. Therefore, with a recovery rate of zero, the extreme loss given default is $1,000,000. The expected loss is equal to the portfolio value times $\pi$ and is $20,000 in this example (0.02 × $1,000,000). The credit VaR is defined as the quantile of the credit loss less the expected loss of the portfolio. At the 99% confidence level, the credit VaR is equal to $980,000 ($1,000,000 minus the expected loss of $20,000).

4. **B** The conditional distribution is a normal distribution with a mean of $\beta_i \bar{m}$ and a standard deviation of $\sqrt{1-\beta_i^2}$ .

5. **D** A default loss level of 0.01 corresponds to –2.33 on the standard normal distribution. The realized market value is computed as follows:

$$-2.33 = \frac{-2.33 - (0.5)\bar{m}}{\sqrt{1-0.5^2}}$$

$$-2.33(0.86603) = -2.33 - (0.5)\bar{m}$$

$$-2.01785 + 2.33 = -(0.5)\bar{m}$$

$$0.31215 = -(0.5)\bar{m}$$

$$-0.62430 = \bar{m}$$

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Structured Credit Risk

Topic 25

## Exam Focus

In this topic, we discuss common structured products, capital structure in securitization, structured product participants, a basic waterfall structure, and the impact of correlation. For the exam, understand the qualitative impacts of changing default probability and default correlation for all tranches for mean (average) and risk (credit VaR). Default sensitivity (similar to DV01) is introduced. Understand the process to compute implied correlation extracted from observable market prices.

## Types of Structured Products

### LO 25.1: Describe common types of structured products.

Securitization and structured products are two of the most important financial innovations in recent memory. Securitization is basically the pooling of credit-sensitive assets and the associated creation of new securities (structured products or portfolio credit products) whose cash flows are based on underlying loans or credit claims. Each product has its own risk and return characteristics, which can vary dramatically from the original assets. For this LO, a partial list of structured products and factors that affect their valuation are discussed.

**Covered bonds**. Covered bonds are on-balance sheet securitizations. A pool of mortgages, which secure a bond issue, is separated from other loans into a covered pool on the originator's balance sheet. Investors have higher priority than general creditors if a bank defaults. Principal and interest is paid and guaranteed by the originator and is not based on the performance of the underlying assets themselves. Thus, covered bonds are not true securitizations since the assets are not part of a bankruptcy-remote structure and the investors have recourse against the originator.

**Mortgage pass-through securities**. In contrast to covered bonds, mortgage pass-through securities are true off-balance sheet securitizations. Investors receive cash flows based entirely on the performance of the pool less associated fees paid to the servicer. Most pass-throughs are agency mortgage-backed securities (MBS) that carry implicit or explicit government guarantee of performance. Thus, default risk is not a serious concern. The primary risk is due to prepayment of principal by the homeowner, most likely from refinancing after interest rate declines or home sales.

**Collateralized mortgage obligations** (CMOs). CMOs are MBSs that tranche (i.e., divide) cash flows into different securities based on predetermined conditions. The resulting tranches can have long or short maturities, fixed or floating cash flows, or other varieties and conditions. The most basic structure is the *waterfall* or *sequential pay structure* where Tranche 1 receives all principal and its portion of interest in each period until it is paid

off. The remaining tranches will receive interest only until Tranche 1 is retired and then principal will flow down to Tranche 2, and so on. Not surprisingly, Tranche 1 will have a very low prepayment risk as it expects to receive all principal payments before other bondholders.

**Structured credit products**. Like other structured products, this pool of assets is backed by risky debt instruments. The difference is that structured credit products create tranches that have different amounts of credit risk. The most junior (i.e., equity) tranches bear the first losses and are most likely to be written down from defaulted assets. If the equity tranche is completely wiped out, the next most junior tranche will bear the credit risk of subsequent defaults. The most senior tranche will have the highest credit rating and the lowest probability of writedowns.

**Asset-backed securities**. This is the most general class of securitizations where cash-flow generating assets are pooled and subsequently tranched. Under this definition, MBS is a special case of the more general ABS. Other varieties include collateralized bond obligations (CBO), collateralized debt obligations (CDO), collateralized loan obligations (CLO), and collateralized mortgage obligations (CMO). There exist even more complex securities that pool other securitizations together such as CDO-squared (CDO of CDOs).

Structured credit products can also vary across other dimensions. First, the underlying collateral of the pool can consist of loans, bonds, credit card receivables, auto loans, and even non-debt instruments that generate cash flows, such as toll collections. Second, the size and number of tranches is specific to each transaction. Third, the pool can be passive or actively managed. In a passive pool, the existing assets, such as mortgages and auto loans, will eventually pay themselves down. On the other hand, actively managed pools will selectively add or shed assets from the pool. Managers with key insight should be able to enhance the performance of the pool by identifying overvalued and undervalued loan products. Revolving pools have a period of time where loan proceeds are reinvested in new assets. Once the revolving period ends, the asset balances are fixed (e.g., credit card balances) and will spend themselves down.

## Capital Structure in Securitization

### LO 25.2: Describe tranching and the distribution of credit losses in a securitization.

The capital structure of a securitization refers to the priority assigned to the different tranches. In general, the most **senior tranches** at the top of the capital structure will have the highest priority to receive principal and interest. Since these securities are perceived to be the safest, they also receive the lowest coupon.

The **equity tranche** is the slice of the cash flow distribution with the lowest priority and will absorb the first losses up to a prespecified level. These securities typically do not carry a fixed coupon but receive the residual cash flows only after the other security claims are satisfied. Therefore, the return is variable and, hence, the term “equity.” Typically, the equity tranche is the smallest part of the capital structure.

Between the senior and equity tranches is the **mezzanine tranche** (i.e., the junior tranche). The mezzanine tranches will absorb losses only after the equity tranche is completely written down. Thus, the senior tranches are protected by both the equity and mezzanine debt (termed subordination or credit enhancement). Terminology-wise, the mezzanine debt attaches to the equity tranche from above and detaches from the senior tranche from below. These junior debt claims offer a relatively high coupon (if the claim is fixed) or high spread (if the claim is floating). To keep the securitization viable, the mezzanine tranches will be purposefully thin.

There are many creative ways to provide credit protection to various security classes, but this must come at the expense of shifting risk to other parts of the capital structure. In general, credit enhancement can be divided into internal and external credit enhancement mechanisms. The term **external credit enhancement** means that the credit protection takes the form of insurance or wraps purchased from a third party, typically a monoline insurer.

Two examples of **internal credit enhancements** are overcollateralization and excess spread. **Overcollateralization** is when the pool offers claims for less than the amount of the collateral. For example, consider a collateralized MBS with 101 mortgages in the collateral pool, but the face value of the bonds across all tranches only totals 100 mortgages. Overcollateralization is a *hard credit enhancement* because the protection is available at the origination of the pool.

The **excess spread** is the difference between the cash flows collected and the payments made to all bondholders. For example, if the weighted average of the collateral is 8% (net of fees) and the weighted average of the payments promised to the senior, junior, and equity tranches is 7%, then the residual 1% accumulates in a separate trust account. The excess spread will be invested and is available to make up future shortfalls. Since the excess spread is zero at origination, it is considered a *soft credit enhancement*.

## Waterfall Structure

### LO 25.3: Describe a waterfall structure in a securitization.

A waterfall structure outlines the rules and conditions that govern the distribution of collateral cash flows to different tranches. In the simplest example of a securitization, the senior and junior bonds will receive their promised coupons conditional on a sufficient amount of cash inflows from the underlying loans. The residual cash flow, if any, is called the excess spread. The overcollateralization triggers will decide how the excess is divided between the equity investors and the accumulating trust. Intuitively, the underlying cash flows will be largest in the earlier periods so the trust will build up a reserve against future shortfalls.

In practice, this process can be quite complex as there may be a dozen tranches or more with different coupons, maturities, and overcollateralization triggers. The waterfall is further complicated by loan defaults. A simplifying assumption would incorporate a constant default rate which can be built into the waterfall distribution. As the loans mature, the actual incidence of the loan defaults will increase or decrease the value of the respective tranches. For example, suppose that fewer loans default than previously assumed, then

collateral cash flows are larger than expected and will benefit all bondholders, in particular, the equity tranche.

Let's analyze the cash flows in a waterfall structure by considering the following examples. Assume there are 1,000 identical loans with a value of $1 million each. The interest rate on the loans is floating with a rate equal to LIBOR + 300 bps, reset annually. The senior, junior, and equity tranches are 80%, 15%, and 5% of the pool, respectively. The spreads on the senior and mezzanine tranches are 1% and 5%. There is one overcollateralization trigger where the equity holders are entitled to a maximum of $15 million and any excess is diverted to the excess trust account. To begin, assume the default rate is 0%. The cash flows for the waterfall structure are detailed in Figure 1.

**Figure 1: Waterfall Structure (Default Rate = 0%)**

| *Loan Information* | |
|---|---|
| # loans | 1,000 |
| $ value of identical loan | $1,000,000 |
| Principal amount | $1,000,000,000 |
| LIBOR | 5.00% |
| Spread | 3.00% |
| Coupon | 8.00% |
| Default rate | 0.00% |
| OC trigger | $15,000,000 |

| *Tranche Information* | | | |
|---|---|---|---|
| Senior % of pool | | 80% | |
| | LIBOR | | 5.00% |
| | Spread | | 1.00% |
| | Coupon | | 6.00% |
| Mezzanine % of pool | | 15% | |
| | LIBOR | | 5.00% |
| | Spread | | 5.00% |
| | Coupon | | 10.00% |
| Equity % of pool | | 5% | |

| *Period* | *Loan Proceeds* | |
|---|---|---|
| 1 | $80,000,000 | |
| *Senior Principal* | *Senior Coupon* | *Interest* |
| $800,000,000 | 6.00% | $48,000,000 |
| *Mezzanine Principal* | *Mezzanine Coupon* | *Interest* |
| $150,000,000 | 10.00% | $15,000,000 |
| *Excess CF* | *CF to Equity* | *CF to Trust* |
| $17,000,000 | $15,000,000 | $2,000,000 |

Note that the senior tranche has a principal value of $800 million while the junior tranche has an initial principal of $150 million. Using a current LIBOR of 5%, their respective coupons are 6% (5% + 1% spread) and 10% (5% + 5% spread). The total cash flows flowing into the pool are $1 billion × 8% = $80 million, which is sufficient to pay the senior and junior claims. The residual cash flow is $80 million – ($48 million + $15 million) = $17 million.

Next, the overcollateralization test must be applied. Since the maximum the equity tranche can receive is $15 million, the equity investors will receive the full $15 million and the excess of $2 million will flow into the trust account. This is shown in the last row of Figure 1.

Now assume that the expected default rate is 4% each year. The first difference from the 0% default rate example is that the total loan proceeds is reduced by defaulted loans: $1 billion × 8% × (1 – 0.04) = $76.8 million. There is still sufficient cash flow to pay the senior and junior bondholders in full. However, when the overcollateralization test is applied, the equity holders will not reached their maximum. Therefore, the equity tranche receives only $13.8 million and there is no diversion to the trust account as shown in Figure 2.

**Figure 2: Waterfall Structure (Default Rate = 4%)**

| *Loan Information* | |
|---|---|
| # loans | 1,000 |
| $ value of identical loan | $1,000,000 |
| Principal amount | $1,000,000,000 |
| LIBOR | 5.00% |
| Spread | 3.00% |
| Coupon | 8.00% |
| Default rate | 4.00% |
| OC trigger | $15,000,000 |

| *Tranche Information* | | | |
|---|---|---|---|
| Senior % of pool | | 80% | |
| | LIBOR | | 5.00% |
| | Spread | | 1.00% |
| | Coupon | | 6.00% |
| Mezzanine % of pool | | 15% | |
| | LIBOR | | 5.00% |
| | Spread | | 5.00% |
| | Coupon | | 10.00% |
| Equity % of pool | | 5% | |

**Figure 2 Cont.: Waterfall Structure (Default Rate = 4%)**

| *Period* | *Loan Proceeds* | |
|---|---|---|
| 1 | $76,800,000 | |
| *Senior Principal* | *Senior Coupon* | *Interest* |
| $800,000,000 | 6.00% | $48,000,000 |
| *Mezzanine Principal* | *Mezzanine Coupon* | *Interest* |
| $150,000,000 | 10.00% | $15,000,000 |
| *Excess CF* | *CF to Equity* | *CF to Trust* |
| $13,800,000 | $13,800,000 | $0 |

## Securitization Participants

### LO 25.4: Identify the key participants in the securitization process, and describe conflicts of interest that can arise in the process.

The nature of the securitization process from original loan to tranche issuance necessarily involves many different participants. The first step begins with the **originator** who funds the loan. The originator may be a bank, mortgage lender, or other financial intermediary. The term "sponsor" may be used if the originator supplies most of the collateral for the issue.

The **underwriter** performs a function similar to the issuance of traditional debt and equity. The underwriter structures the issue (i.e., engineers the tranche size, coupon, and triggers, and sells the bonds to investors). The underwriter warehouses the collateral and faces the risks that the issue will not be marketed or that the collateral value will drop.

The **credit rating agencies** (CRAs) are an important part of the securitization process. Without their explicit approval via credit ratings, investors would be at a severe disadvantage to assess the riskiness of the issue. The credit rating agencies can influence the size of the tranches by selecting the attachment points and thus are active participants in the process. In addition, the CRAs may influence the issue by requiring enhancements. There is a natural conflict of interest because the CRAs want to generate profit and grow their business, but it may come at the expense of allocating larger portions of the capital structure to lower interest paying senior notes. Investors can alleviate this concern by performing their own (costly) analysis or purchasing a wrap or insurance against the issue.

The role of the servicer is multifaceted and possibly understated. The servicer must collect and distribute the collateral cash flows and the associated fees. In addition, the servicer may need to provide liquidity if payments are late and resolve default situations. It is not hard to envision the conflict of interest in foreclosure: the servicer would, all else equal, like to delay foreclosure to increase their fees, while investors want as quick of a resolution as possible to minimize the damage and/or lack of maintenance from the homeowners who have no economic incentive to maintain the property.

When the pool is actively managed, another source of conflict arises. The manager naturally would like to minimize their effort to continually monitor the credit quality of the collateral unless there is a clear incentive to do so. A common feature of securitized pools is for the originator and/or manager to bear the first loss in the capital structure.

Custodians and trustees play an administrative role verifying documents, disbursing funds, and transferring funds between accounts.

## Three-Tiered Securitization Structure

### LO 25.5: Evaluate one or two iterations of interim cashflows in a three tiered securitization structure.

The cash flows in a three-tiered securitization (senior, mezzanine, and equity) can be broken out into the inflows from the collateral and the outflows to the investors. The inflows prior to maturity are the interest on the collateral ($L_t$) plus the recovery from the sale of any defaulted assets in the current period ($R_t$). Assume the collateral pool has $N$ identical loans with coupons = LIBOR + spread. The terminal cash flows in the final year are the last interest payment plus principal and recovery of defaulted assets. As an additional consideration, the recovered funds from defaults would earn interest over the remaining life of the pool at $r$.

The outflows are the coupon payments paid to senior and mezzanine note holders, collectively denoted $B$ (assumed constant). The equity holder position is a bit more complicated because the excess spread trust has first priority on the cash flows to provide soft credit enhancement to the more senior tranches. Specifically, the equity holders' cash flows are dependent on the amount of inflows to the pool less any funds diverted to the excess spread account. Denote the amount diverted to the spread trust in year $t$ as ($OC_t$) with maximum allowable diversion $K$. To determine the cash flow to equity, the following steps must be performed:

1. Is the current period interest sufficient to cover the promised coupons: $L_t - B \geq 0$? If *yes*, then the following overcollateralization test must be performed to see how much flows to trust: Is $L_t - B \geq K$? If *yes*, then $K$ is diverted to trust, and $L_t - B - K$ flows to equity holders: $OC_t = K$. If *no*, then $L_t - B$ is diverted to trust, and nothing flows to equity holders: $OC_t = L_t - B$

2. Is the current period interest sufficient to cover the promised coupons: $L_t - B \geq 0$? If *no*, then the interest is not sufficient to pay bondholders and all $L_t$ flows to bondholders. Therefore, the shortfall is $B - L_t$. The next step is to check if the accumulated funds in the spread trust can cover the shortfall. If the trust account has enough funds, the bondholders can be paid in full. If the trust account does not have enough funds, then the bondholders suffer a writedown.

The previous steps outlined the basic procedure for tranche cash flow distribution; however, a few more factors need to be considered. First, for each period there are possible defaults. For simplicity, assume the number of defaults ($d_t$) is constant for each period. Second, the amount recovered in year $t$ (assuming a 40% recovery rate) equals:

$$R_t = 0.4d_t \times \text{loan amount}$$

Therefore, the total amount deposited into the trust account in year *t* is:

$$R_t + OC_t$$

It follows that the total amount accumulated in the trust account in year *t* is:

$$R_t + OC_t + \sum_{\tau=1}^{t-1}(1+r)^{t-\tau}OC_\tau$$

Now, if excess spread is negative ($L_t - B < 0$), the custodian must check if the trust account can cover the shortfall. Formally, the test for the custodian is:

$$R_t + \sum_{\tau=1}^{t-1}(1+r)^{t-\tau}OC_\tau > B - L_t$$

Note that there is no $OC_t$ term to add to $R_t$ since there is no excess spread this period. If the above test is true, then the trust account can make the bondholders whole. If it is not true, then the fund is reduced to zero and bondholders receive $R_t + \sum_{\tau=1}^{t-1}(1+r)^{t-\tau}OC_\tau$ from the trust account.

Using the previous exposition, the amount diverted to the overcollateralization account can be calculated as:

$$OC_t = \begin{Bmatrix} \min(L_t - B, K) \\ \max\left[L_t - B, -\sum_{\tau=1}^{t-1}(1+r)^{t-\tau}OC_\tau + R_t\right] \end{Bmatrix} \text{for} \begin{Bmatrix} L_t \geq B \\ L_t < B \end{Bmatrix}$$

Note that the upper condition represents inflows to the trust account while the lower condition represents outflows from the trust account.

Finally, the equity cash flows can be expressed as:

$$\max(L_t - B - OC_t, 0) \text{ for } t = 1,\ldots,T-1$$

The cash flows in the final year must be examined separately for several reasons. First, the surviving loans reach maturity and principal is returned. Second, there is no diversion to the trust account because the structure ends and all proceeds follow the waterfall. Third, since there is no diversion to the trust, there is no need to test overcollateralization triggers.

The terminal cash flows are summarized as follows:

1. Loan interest = $\left(N - \sum_{t=1}^{T} d_t\right) \times$ (LIBOR + spread) × par
2. Proceeds (par) from redemption of surviving loans = $\left(N - \sum_{t=1}^{T} d_t\right) \times \text{par}$

3. Recovery in final year: $R_T = 0.4d_T \times \text{par}$

4. Residual in trust account: $\sum_{\tau=1}^{T}(1+r)^{t-\tau}OC_t$

The sum of these terminal cash flows is compared to the amount due to the senior tranche. If the sum is large enough, the senior tranche is paid off and the remainder is available for the rest of the capital structure. If the remainder is large enough to cover the junior tranche, then the residual flows to equity. If the remainder cannot meet junior claims, the junior bonds receive the excess and equity holders receive nothing.

As an example, determine the terminal cash flows to senior, junior, and equity tranches given the following information. The original loan pool included 100 loans with $1 million par value and a fixed coupon of 8%. The number of surviving loans is 90. The par for the senior and junior tranches is 75% and 20%, respectively. The equity investors contributed the remaining 5%. There were two defaults with recovery rate of 40% recovered at the end of the period. The value of the trust account at the beginning of the period is $16 million earning 4% per annum.

1. Total size of collateral pool at origination: 100 × $1,000,000 = $100,000,000

2. Senior tranche = $75,000,000
   Junior tranche = $20,000,000
   Equity tranche = $5,000,000

| | |
|---|---|
| 3. Interest from loans: 90 × 8% × $1,000,000 = | $7,200,000 |
| 4. Redemption at par: 90 × $1,000,000 = | $90,000,000 |
| 5. Recovery in final year: 2 × 40% × $1,000,000 = | $800,000 |
| 6. Value of OC at end of final year: $16,000,000 × 1.04 = | $16,640,000 |
| 7. Total available to satisfy all claims = | $114,640,000 |

8. Senior claim = $75,000,000 < $114,640,000. Senior claim is satisfied w/o impairment
9. Junior claim = $20,000,000 < $114,640,000 – $75,000,000 so junior claim is satisfied
10. Equity claim = $114,640,000 – $75,000,000 – $20,000,000 = $19,640,000

Now, continue with the same example, but change the interest rate to 5% and the beginning OC value to $3 million. The first two steps will be the same as before.

| | |
|---|---|
| 3. Interest from loans: 90 × 5% × $1,000,000 = | $4,500,000 |
| 4. Redemption at par: 90 × $1,000,000 = | $90,000,000 |
| 5. Recovery in final year: 2 × 40% × $1,000,000 = | $800,000 |
| 6. Value of OC at end of final year: $3,000,000 × 1.04 = | $3,120,000 |
| 7. Total available to satisfy all claims = | $98,420,000 |

8. Senior claim = $75,000,000 < $98,420,000. Senior claim is satisfied w/o impairment
9. Junior claim = $20,000,000 < $98,420,000 – $75,000,000 so junior claim is satisfied
10. Equity claim = $98,420,000 – $75,000,000 – $20,000,000 = $3,420,000

Finally, continue with the same example, but change the interest rate to 4% and the beginning OC value to $1 million. Assume a recovery rate of zero. Again, the first two steps are the same as before.

| | | |
|---|---|---:|
| 3. | Interest from loans: 90 × 4% × $1,000,000 = | $3,600,000 |
| 4. | Redemption at par: 90 × $1,000,000 = | $90,000,000 |
| 5. | Recovery in final year: 2 × 0% × $1,000,000 = | 0 |
| 6. | Value of OC at end of final year: $1,000,000 × 1.04 = | $1,040,000 |
| 7. | Total available to satisfy all claims = | $94,640,000 |

8. Senior claim = $75,000,000 < $94,640,000. Senior claim is satisfied w/o impairment
9. Junior claim = $20,000,000 > $94,640,000 – $75,000,000 so junior claim is impaired
   Junior tranche receives $19,640,000
10. Equity claim = $94,640,000 – $75,000,000 – $20,000,000 < 0
    Equity tranche receives $0

## Simulation Approach

**LO 25.6: Describe a simulation approach to calculating credit losses for different tranches in a securitization.**

The prior analysis made a few very important simplifying assumptions. In particular, the analysis assumed that the default rate was constant year over year, each loan exhibited the same default probability, and the correlation between loans was ignored. In practice, these assumptions need to be brought into the analysis and the only tractable way to do so is via simulation.

Although the technical details are well beyond the scope of the exam, we can sketch out the basic steps and intuition for the simulation approach to calculating credit losses.

*Step 1:* Estimate the parameters.
*Step 2:* Generate default time simulations.
*Step 3:* Compute portfolio credit losses.

The first step is to estimate the critical parameters, default intensity, and pairwise correlations. The default intensity can be estimated using market spread data to infer the hazard rate across various maturities. This piecewise-bootstrapping methodology to construct the cumulative default distribution was discussed in Topic 23. Estimating the correlation coefficients is more challenging because of a lack of usable market data. The copula correlation could be useful in theory but suffers empirical precision in practice. Instead, a sensitivity analysis is performed for various default and correlation pairs.

The second step identifies if and when the security defaults. Simulation provides information on the timing for each hypothetical outcome. The third step uses the simulation output to determine the frequency and timing of credit losses. The credit losses can be "lined up" to assess the impact on the capital structure losses. The tail of the distribution will identify the credit VaR for each tranche in the securitization.

## Impact of Probability of Default and Default Correlation

**LO 25.7: Explain how the default probabilities and default correlations affect the credit risk in a securitization.**

There are several important comparative statistics associated with a generic securitization. The following results represent the effect of the average tranche values and writedowns. The implications of extreme tail events will be discussed shortly using VaR. The first factor to consider is the probability of default. It is straightforward to see that, for a given correlation, increasing the probability of default will negatively impact the cash flows and, thus, the values of all tranches.

The effect of changing the correlation is more subtle. Consider the stylized case where the correlation is very low, say zero, so loan performance is independent. Therefore, in a large portfolio, it is virtually impossible for none of the loans to default and it is equally unlikely that there will be a large number of defaults. Rather, the number of defaults should be very close to the probability of default times the number of loans. So, the pool would experience a level of defaults very close to its mathematical expectation and is unlikely to impair the senior tranches. The analogous situation is flipping a coin 1,000 times—the number of heads would be very close to 500. It would be virtually impossible for the number of heads to be less than 400 or greater than 600. Now, if the correlation increases, the default of one credit increases the likelihood of another default. Thus, increasing correlation decreases the value of senior tranches as the pool is now more likely to suffer extreme losses. This effect is exacerbated with a higher default probability.

Now consider the equity tranche. Recall that the equity tranche suffers the first writedowns in the pool. Therefore, a low correlation implies a predictable, but positive, number of defaults. In turn, the equity tranche will assuredly suffer writedowns. On the other hand, if the correlation increases, the behavior of the pool is more extreme, and there may be high levels of related losses or there may be very few loan losses. In sum, the equity tranche increases in value from increasing correlation as the possibility of zero (or few) credit losses increases from the high correlation.

The correlation effect on the mezzanine tranche is more complex. When default rates are low, increasing the correlation increases the likelihood of losses to the junior bonds (similar to senior bonds). However, when default rates are relatively high, increasing the correlation actually decreases the expected losses to mezzanine bonds as the possibility of few defaults is now more likely. Accordingly, the mezzanine bond mimics the return pattern of the equity tranche. In short, increasing correlation at low default rates decreases mezzanine bond values, but at high default rates it will increase mezzanine bond values.

Convexity is also an issue for default rates. For equity investors, as default rates increase from low levels, the equity tranche values decrease rapidly then moderately (a characteristic of positive convexity). Since the equity tranche is thin, small changes in default rates will disproportionately impact bond prices at first. Similarly, senior tranches exhibit negative convexity. As defaults increase, the decline in bond prices increases. As usual, the mezzanine impact is somewhere in between: negative convexity at low default rates, positive convexity at high default rates.

The previous section focused on the average (mean) value of the tranches while this section examines the distribution of possible tranche values (risk). Specifically, the goal is to analyze the impact of default probability and default correlation under extreme conditions (far into the tail). The metric used is credit VaR for various ranges of default probability and default correlation for the senior, junior, and equity tranches. The main result is that increasing default probability, while holding correlation constant, generally decreases the VaR for the equity tranches (less variation in returns) and increases the VaR for the senior tranches (more variation in returns). As usual, the mezzanine effect is mixed: VaR increases at low correlation levels (like senior bonds) then decreases at high correlation levels (like equity). These results are summarized in Figure 3.

**Figure 3: Increasing Default Probability (Holding Correlation Constant)**

| | *Mean value* | *Credit VaR* |
|---|---|---|
| Equity tranche | ↓ | ↓ |
| Mezzanine tranche | ↓ | ↑ then ↓ |
| Senior tranche | ↓ | ↑ |

The next effect to consider is the impact of a rising correlation. As a reminder, increasing correlation increases the clustering of events, either high frequency of defaults or very low frequency of defaults. Increasing correlation decreases senior bond prices as the subordination is more likely to be breached if defaults do indeed cluster. In contrast, equity returns increase as the low default scenario is more probable relative to low correlation where defaults are almost certain.

As the default correlation approaches one, the equity VaR increases steadily. The interpretation is that although the mean return is increasing so is the risk as the returns are more variable (large losses or very small losses).

All else equal, the senior VaR also increases consistently with correlation. However, we note an interesting effect: the incremental difference between high correlations (0.6 versus 0.9) is relatively small. In addition, two pairwise results are worth highlighting. If correlation is low and default frequency is relatively high, then senior bonds are well insulated. In fact, at the 10% subordination level, the senior bonds would be unaffected even at a high default rate. At the other extreme, when correlations are high (0.6 or above), then the VaRs are quite similar regardless of the default probability. Hence, generally speaking, correlation is a more important risk factor than default probability which may not be entirely intuitive.

The implications for the mezzanine tranche are, again, mixed. When default rates and correlations are lower, the mezzanine tranche behaves more like senior notes with low VaRs. However, when the default probabilities are higher and/or pairwise correlation is high, the risk profile more closely resembles the equity tranche. These results are summarized in Figure 4.

**Figure 4: Increasing Correlations (Holding Default Probability Constant)**

| | *Mean value* | *Credit VaR* |
|---|---|---|
| Equity tranche | ↑ | ↑ |
| Mezzanine tranche | ↓(at low default rates)<br>↑(at high default rates) | ↑ |
| Senior tranche | ↓ | ↑ |

## Measuring Default Sensitivities

### LO 25.8: Explain how default sensitivities for tranches are measured.

The previous discussion highlighted the effect of increasing the probability of default, which decreases tranche values. However, this effect is not necessarily linear and also depends on the interaction with the default correlation. To analyze the marginal effects in more detail, the definition of DV01 is extended to default probabilities and is called "default '01." The default probability will be shocked up and down by the same amount (by convention 10 basis points) and each tranche will be revalued through the VaR simulations. The formulation for default '01 of each tranche is as follows:

$$1/20\ [(\text{mean value / loss based on } \pi + 0.001) - (\text{mean value / loss based on } \pi - 0.001)]$$

From this equation, there are several qualitative impacts to note. First, the default sensitivities are always positive for any default probability-correlation combination. This follows from the previous observation that all tranches are negatively affected from increasing default probabilities. Second, the default '01 will approach zero as default rates become sufficiently high as the marginal impact of increasing the default rate has minimal effect. The third result follows from the second. There will be more variation in the default sensitivities when the default rate generates losses close to the tranche's attachment point. This result is similar to the high gamma (high sensitivity in delta) for options at-the-money.

## Risks for Structured Products

### LO 25.9: Describe risk factors that impact structured products.

Aside from the credit portfolio modeling issues discussed before, there are at least three other risks that deserve discussion: systematic risk, tranche thinness, and loan granularity.

Similar to a well-diversified equity portfolio that cannot eliminate systematic risk, the same holds true for credit portfolios. Unfortunately, even when the collateral pool is well-diversified among lenders, terms, geography, and other factors, high systematic risk expressed in high correlations can still severely damage a portfolio. As previously discussed, with increases in pairwise correlations, the likelihood of senior tranche writedowns increases as well.

The equity and mezzanine tranches are relatively thin. This also manifests itself in the relative closeness of the 95% and 99% credit VaR. The implication is that given that the tranche has been breached, the loss is likely very large.

Loan granularity references the loan level diversification. For example, in a collateralized MBS pool, the portfolio composition is a few loans but the loans are of substantial size. This reduction in sample size increases the probability of tail events in relation to an equal sized portfolio constructed with more loans of smaller amounts.

## Implied Correlation

### LO 25.10: Define implied correlation and describe how it can be measured.

The implied correlation is a very similar concept to the implied volatility of an equity option. For options, the Black-Scholes-Merton model is a widely accepted valuation model and so the observable market price is associated with a unique unobserved volatility. For securitized tranches, the process is exactly the same. Starting with observed market prices and a pricing function for the tranches, it is possible to back out the unique implied correlation to calibrate the model price with the market price.

The mechanical part of the process involves several intermediate steps. First, the observable credit default swap (CDS) term structure is used to extract risk-neutral default probabilities and possibly recovery rates. Assuming constant pairwise correlation and market prices for the respective tranches, the default estimates and correlation estimates can be fed into a copula. The output is the risk-neutral implied correlation (i.e., base correlation) per tranche. The correlation estimates will vary between the tranches and are not likely to be constant giving rise to correlation skew. As an example, suppose the observed market price of the equity tranche increases from $3 million to $3.2 million, but the estimates of the risk-neutral probability of default remain the same. It can be inferred that the market's estimate of the implied correlation must have increased. The precise value must be extracted from the pricing model but qualitatively the direction is correct; increasing correlations benefit equity holders.

## Motivations for Using Structured Products

### LO 25.11: Identify the motivations for using structured credit products.

Identifying the motivations of loan originators and investors can provide a better understanding for why securitizations are established.

Loan originators, who help create securitizations by selling loans into a trust, are attracted to borrowing via securitization given its ability to provide a lower cost of funding. Without securitization, loans would either be retained or sold in the secondary market. These alternatives would likely be more costly than securing funding via securitization. A lower cost of funding can be obtained given the diversification of the loan pool and the reputation of the originator for underwriting high-quality loans. However, some loan pools, such as commercial mortgage pools, can be difficult to diversify. Thus, an element of systematic risk

may still exist, which could lead to an underestimation of overall risk. An additional benefit of securitization for loan originators is the collection of servicing fees.

Investors, who purchase the assets in a securitization, are attracted to investing in diversified loan pools that they would not otherwise have access to without securitization, such as mortgage loans and auto loans. In addition, the ability to select a desired risk-return level via tranching offers another advantage for investors. Equity tranches will offer higher risk-return levels, while senior tranches will offer lower risk-return levels. However, it is important for investors to conduct the proper due diligence when analyzing potential tranche investments in order to understand the actual level of risk involved.

## Key Concepts

### LO 25.1

Securitization is the process of pooling cash flow generating assets and reapportioning the cash flows into bonds. These structured products generate a wide range of risk-return profiles that vary in maturity, credit subordination (equity, mezzanine, and senior), type of collateral (mortgages, auto loans, and credit card balances), active or passive management, and static or revolving assets. A true securitization removes the assets from the originator's balance sheet.

### LO 25.2

The capital structure of a securitization refers to the different size and priority of the tranches. In general, the senior tranches are the largest, safest, and lowest yielding bonds in the capital structure. The mezzanine tranche has lower priority than the senior tranche and is promised a higher coupon. The lowest priority tranche that bears the first loss is the equity tranche. The size of the equity and mezzanine tranches provides subordination for the senior tranche. Internal credit enhancement, such as overcollateralization and excess spread, buffers the senior tranches from losses. Likewise, external wraps and insurance also protect the senior bondholders.

### LO 25.3

A waterfall structure details the distribution of collateral cash flows to the different classes of bondholders. The equity tranche typically receives the residual cash flows once the senior and mezzanine investor claims are satisfied. If the cash flows to equity holders exceed the overcollateralization trigger, the excess is diverted to a trust account. Fees and defaults will reduce the net cash flows available for distribution.

### LO 25.4

Securitization is a complicated process and typically involves an originator, underwriter, credit rating agency, servicer, and manager. The originator creates the initial liability; the underwriter pools and structures the terms of the deal as well as markets the issue; the credit rating agency is an active participant suggesting/requiring sufficient subordination and enhancements to justify the ratings; the servicer collects and distributes the cash flows to investors and manages distress resolution; managers, both static and active, usually bear the first loss to mitigate conflict of interest in asset selection and credit monitoring.

## LO 25.5

The three-tiered waterfall will have scheduled payments to senior and mezzanine tranches. The equity tranche receives cash flows only if excess spread > 0 (i.e., interest collected > interest owed to senior + mezzanine). The overcollateralization account increases from recovery of defaulted assets and diversion of spread (usually a maximum is predetermined) and earns the money market rate. If excess spread is negative (i.e., interest collected < interest owed to senior + mezzanine), the OC account will use all of its available funds until depleted. The terminal cash flows are more complicated: redemptions at par + interest from surviving loans + recovery in final period + terminal OC account. No funds are diverted in the final year as it all is aggregated and disbursed. Senior claims are paid first; if senior is paid in full, mezzanine claims are paid; if mezzanine is paid in full, the residual accrues to equity holders.

## LO 25.6

Simulation is a useful technique to provide more insight into the performance of the collateral and, hence, cash flows to the tranches. In particular, the default intensity can be time-varying and estimated using a hazard distribution. The correlation between loans is critical to the performance of the pool, so various default probability/correlation pairs are used. Copulas could be used to simulate the timing of the defaults. Finally, simulations allow computation of VaRs for each tranche.

## LO 25.7

Increasing default probability will decrease all tranches unconditionally. In contrast, increasing correlation will impact each tranche differently. In general, increasing default correlation increases the likelihood of extreme portfolio behavior (very few or many defaults).

Credit VaR can be used to measure the value of the tranches in the left tail. Increasing the correlation increases the VaR of all tranches. In contrast, increasing the probability of default decreases equity VaR and increases senior VaR.

## LO 25.8

Default sensitivities are measured analogously to DV01 and spread ‘01 by shocking the default probability up and down by 10 basis points. Default sensitivities are always positive and are largest when the resulting loss is close to the attachment point.

## LO 25.9

Similar to equity portfolios, systematic risk is present in credit portfolios. Extreme loss events are captured by high default correlations. The thinness of the equity and mezzanine tranches implies that conditional losses are likely to be large. A less granular pool (fewer but larger loans) is more likely to experience a tail event, all else equal.

## LO 25.10

Implied default correlations for each tranche can be backed out of the tranche pricing model similar to how the implied volatility is calculated for the Black-Scholes-Merton model.

## LO 25.11

Loan originators help create securitizations by selling loans into a trust. They are attracted to secured borrowing via securitization because it provides a lower cost of funding than alternatives such as retaining loans. Investors purchase the bonds and equity in a securitization. They are attracted to securitization because it allows them to invest in diversified loan pools that are typically reserved for banks.

## Concept Checkers

1. How many of the following statements concerning the capital structure in a securitization are most likely correct?

   I. The mezzanine tranche is typically the smallest tranche size.
   II. The mezzanine and equity tranches typically offer fixed coupons.
   III. The senior tranche typically receives the lowest coupon.

   A. No statements are correct.
   B. One statement is correct.
   C. Two statements are correct.
   D. Three statements are correct.

2. Assume there are 100 identical loans with a principal balance of $500,000 each. Based on a credit analysis, a 300 basis point spread is applied to the borrowers. LIBOR is currently 4% and the coupon rate will reset annually. The senior, junior, and equity tranches are 75%, 20%, and 5% of the pool, respectively. The spreads on the senior and mezzanine tranches are 2% and 6%. Excess cash flow is diverted above $1,000,000. Assume the default rate is 2%. What are the cash flows to the mezzanine and excess trust account in the first period?

| | Mezzanine | Trust account |
|---|---|---|
| A. | $1,000,000 | $0 |
| B. | $1,000,000 | $180,000 |
| C. | $2,250,000 | $200,000 |
| D. | $2,250,000 | $250,000 |

3. Which of the following participants in the securitization process is least likely to face a conflict of interest?
   A. Credit rating agency and servicer.
   B. Servicer and underwriter.
   C. Custodian and trustee.
   D. Trustee and manager.

4. Which of the following statements about portfolio losses and default correlation are most likely correct?

   I. Increasing default correlation decreases senior tranche values but increases equity tranche values.
   II. At high default rates, increasing default correlation decreases mezzanine bond prices.

   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

5. Which of the following statements best describes the calculation of implied correlation?
   A. The implied correlation for the mezzanine tranche assumes non-constant pairwise correlation.
   B. Observable market prices of credit default swaps are used to infer the tranche values.
   C. The tranche pricing function is calibrated to match the model price with the market price.
   D. The risk-adjusted default probabilities are used in model calibration.

## Concept Checker Answers

1. **B** Senior tranches are perceived to be the safest, so they receive the lowest coupon. The equity tranche receives residual cash flows and no explicit coupon. Although the mezzanine tranche is often thin, the equity tranche is typically the thinnest slice.

2. **A** The interest rate on the loans = 4% (LIBOR) + 3% (spread) = 7%. Therefore, the total collateral cash flows in the first period = 100 × \$500,000 × 7% × (1 – 0.02) = \$3,430,000. The senior tranche receives \$50 million × 0.75 × (4% + 2%) = \$2,250,000. Similarly, the mezzanine tranche receives \$50 million × 0.20 × (4% + 6%) = \$1,000,000. Next, the residual cash flows are calculated: \$3,430,000 – \$2,250,000 – \$1,000,000 = \$180,000. Since \$180,000 < \$1,000,000, all cash flows are claimed by the equity investors and there is no diversion to the trust account.

3. **C** The custodian and trustee play the least important roles in the securitization process. The servicer, originator, underwriter, credit rating agency, and manager all face conflicts of interest to varying degrees.

4. **A** Statement I is true. Increasing default correlation increases the likelihood of more extreme portfolio returns (very high or very low number of defaults). The increased likelihood of high defaults negatively impacts the senior tranche. On the other hand, the increased likelihood of few defaults benefits the equity tranche as it bears first loss. Statement II is false. At high default rates, increasing the correlation increases the likelihood of more extreme portfolio returns which benefits equity investors and mezzanine investors.

5. **C** Starting with observed market prices and a pricing function for the tranches, it is possible to back out the implied correlation to calibrate the model price with the market price. The computation of implied correlation assumes constant pairwise correlation. Both credit default swap and tranche values are observed. Observed tranche values are used in conjunction with risk-neutral default probabilities to compute implied correlation.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Defining Counterparty Credit Risk

Topic 26

## Exam Focus

This topic examines the concept of counterparty credit risk and introduces techniques for mitigating and managing counterparty risk. For the exam, know the basic terminology related to counterparty risk and the definitions and differences among the various credit exposure metrics that are discussed. Also, be familiar with the types of institutions that take on counterparty risk through trading, and have an understanding of how institutions can mitigate and manage this risk.

## Counterparty Risk

### LO 26.1: Describe counterparty risk and differentiate it from lending risk.

**Counterparty risk** is the risk that a counterparty is unable or unwilling to live up to its contractual obligations (i.e., counterparty defaults). Within the context of derivatives contracts, default occurs at some point after inception but prior to the end of the contract term (i.e., presettlement). If default occurs, current and future payments required by the contract will not be made.

**Lending risk** has two notable characteristics: (1) the principal amount at risk is usually known with reasonable certainty (e.g., mortgage at a fixed rate) and (2) only one party (unilateral) takes on risk.

Counterparty risk goes further than lending risk because it takes into account that the value of the underlying instrument is uncertain in terms of absolute amount and in terms of which party will have a subsequent gain or loss. In addition, counterparty risk is bilateral in that each party takes on the risk that the counterparty will default; the party that is "winning" takes on the risk that the party that is "losing" will default.

*Professor's Note: Counterparty risk is typically used to refer to risk that occurs prior to settlement (i.e., presettlement risk). However, the term may occasionally be used with regard to settlement risk, which is the risk stemming from the fact that there may be a difference in timing between when each counterparty performs its contractual obligations at settlement. During this period, default can occur, resulting in a large loss for one party as credit exposure is at its highest level during the settlement process. If not specifically defined, assume counterparty risk refers exclusively to presettlement risk.*

## Transactions With Counterparty Risk

**LO 26.2: Describe transactions that carry counterparty risk and explain how counterparty risk can arise in each transaction.**

Exchange-traded derivatives do not carry counterparty risk because the exchange is usually the counterparty. Therefore, the focus of this topic will be on securities financing transactions and over-the-counter (OTC) derivatives.

**Securities financing transactions** include repos and reverse repos, and securities borrowing and lending.

**Repos** are short-term lending agreements (as short as one day) secured by collateral. The agreement involves a party (the seller or borrower) selling securities to another party (the buyer or lender) for cash, with the seller/borrower buying back the securities at a later date. The lender receives the repo rate, calculated as a risk-free interest charge, plus a counterparty risk charge. Collateral is usually in the form of liquid securities. A haircut is applied to mitigate against the counterparty risk that the borrower will not repay the cash and to mitigate against a decline in the value of the collateral. To illustrate the use of a haircut, assume a 2% haircut on a $100 million loan amount. This means that approximately $102.04 million of securities is required as collateral on a $100 million loan [$100 million / (1 – 0.02) = $102.04 million].

Although reduced by collateral on the loan, counterparty risk still exists in both a repo transaction and a reverse repo transaction (which is a repo, from the perspective of the other party) due to the fact that the seller may fail to repurchase the security at the maturity date (forcing the buyer to liquidate the collateral to recover the cash that was loaned). If securities are used as collateral, risk exists that the market value of the securities will have declined prior to maturity.

Securities borrowing and lending are repos, just with securities involved rather than cash. The associated counterparty risk is similar to that of repos.

**OTC derivatives** include interest rate swaps (the bulk of the transactions), foreign exchange transactions, and credit default swaps (CDSs).

When comparing an interest rate swap to a regular loan, counterparty risk is reduced for the interest rate swap because there is no exchange of principal. The risk lies in the exchange of floating cash payments versus fixed cash payments. The notion of "netting" further reduces counterparty risk because only the difference between the two payments (the net amount) is exchanged periodically. As soon as the counterparty defaults on payments, there is no need for the other party to continue making payments.

**Foreign exchange forwards** carry large counterparty risk due to the need to exchange notional amounts and due to long maturities (thereby increasing the probability that a default will occur at least once).

**Credit default swaps** carry large counterparty risks due to wrong-way risk and significant volatility (thereby increasing the probability that there will be a "losing" party that will

default). Wrong-way risk refers to an increase in exposure when counterparty credit quality worsens. It can be illustrated in a very simplified example whereby a firm invested in Greek sovereign debt wishes to protect its position by purchasing a CDS on Greek sovereign debt from a Greek bank. Assuming a reduction in the rating of Greek sovereign debt, the buyer of the CDS is "winning." However, the ability of the "losing" counterparty (the Greek bank) to meet its obligations will further be impaired as a result of the credit rating decrease.

## Institutions That Take on Counterparty Risk

### LO 26.3: Identify and describe institutions that take on significant counterparty risk.

The institutions that take on counterparty risk through trading activities vary in size, volume, coverage of asset classes, and their willingness (and ability) to post collateral against their positions. At a high level, these institutions (called "derivatives players" in this context) fall into three categories: large, medium, and small.

**Large derivatives players** are large banks (dealers) that trade with each other and with a large number of clients. They tend to have high numbers of OTC derivatives on their books and cover a very wide range of assets, including commodities, equity, foreign exchange, interest rate, and credit derivatives. In addition, they will post collateral against their positions.

**Medium derivatives players** are often smaller banks or financial institutions that also have a large number of clients and conduct a high volume of OTC derivatives trades. While they also cover a wide range of assets, they are not as active in all of them as large players. In addition, it is likely (but not definite) that they will post collateral against positions.

**Small derivatives players** are sovereign entities, large corporations, or smaller financial institutions with specific derivatives requirements that determine the trades they undertake. Trades are done with only a small number of counterparties, and, as expected, they have few OTC derivatives trades on their books. Unlike large and medium players, small players are likely to specialize in just one asset class. They will also differ from larger players in terms of collateral, which if posted will often be illiquid.

While the entities described here take on counterparty risk through trading activity, third parties exist that offer products and services used by market participants to reduce counterparty risks and improve efficiency. These products and services include clearing services, software, trade compression, and collateral management.

## Counterparty Risk Terminology

**LO 26.4: Describe credit exposure, credit migration, recovery, mark-to-market, replacement cost, default probability, loss given default and the recovery rate.**

**Credit exposure** (or simply *exposure*) is the loss that is "conditional" on the counterparty defaulting. It can be illustrated with a financial instrument contract between two parties. After inception, assume Counterparty A has a positive value (it is the creditor and is owed money), and Counterparty B has a negative value (it is the debtor and owes money). If Counterparty B defaults, Counterparty A will suffer a loss on the amount owed.

In quantifying exposure, it is not always the case that the full principal amount is at risk. Therefore, a more relevant calculation is replacement cost, together with an assumption of a zero recovery value. Furthermore, calculations must consider current exposure (current claims and commitments), future exposure (potential future claims), and continent liabilities.

Regarding **credit migration**, the counterparty may default or its credit rating may deteriorate over the term of the contract, especially for long-time horizons. Alternatively, there may be an improvement in credit rating over time. To assess credit migration, we must consider the term structure of **default probability**:

- Future default probability will likely decrease over time, especially for periods far into the future. This is due to the higher likelihood that the default will have already occurred at some earlier point.
- An expected deterioration in credit quality suggests an increasing probability of default over time.
- An expected improvement in credit quality suggests a decreasing probability of default over time.

Empirically, there is mean reversion in credit quality, so the implication is that counterparties with strong credit ratings tend to deteriorate (increasing default probability over time), and those with weak credit ratings tend to improve (more likely to default earlier and less likely later). Default probability of a counterparty can be computed in two ways: a real (historical) measure (identifying the actual default probability) and a risk-neutral measure (computing the theoretical market-implied probability).

**Recovery** is measured by the recovery rate, which is the portion of the outstanding claim actually recovered after default. For example, a recovery rate of 70% suggests a 30% loss. As discussed earlier in the definition of exposure, recovery is not usually considered when pricing credit risk. Related to the concept of recovery is **loss given default** (LGD), which is calculated as 1 – recovery rate.

**Mark-to-market** (MtM) is an accrual accounting measure that is equal to the sum of the MtM values of all contracts with a given counterparty. Although in theory it represents the current potential loss, it fails to consider other factors such as netting, collateral, or hedging. MtM is equal to the present value of all expected inflows less the present value of expected payments (positive if in favor of the party and negative if not). MtM is a measure of replacement cost. However, although generally close, current **replacement cost** is not theoretically the same as the MtM value due to factors such as transaction costs and bid-ask spreads.

## Managing and Mitigating Counterparty Risk

**LO 26.5: Identify and describe the different ways institutions can manage and mitigate counterparty risk.**

### Managing Counterparty Risk

Methods to manage counterparty risk include the following: trading only with high-quality counterparties, cross-product netting, close-out, collateralization, walkaway features, diversifying counterparty risk, and exchanges and centralized clearinghouses.

Trading only with **high-quality counterparties** is a simple and straightforward method for managing counterparty risk. All of these counterparties would have AAA credit ratings and may not be required to provide collateral.

**Cross-product netting** works with derivative transactions that can have both a positive and a negative value. In the case of a default by either counterparty, a netting agreement will allow transactions to be aggregated and reduce the risk for both parties. The legal and operational risks that accompany netting must be considered. For example, legal risk materializes if a netting agreement is found to be legally unenforceable. An example of cross-product netting is as follows (from Counterparty A's perspective):

| | *Counterparty A* | *Counterparty B* |
|---|---|---|
| Trades with positive MtM | +\$20 million | –\$20 million |
| Trades with negative MtM | –\$17 million | +\$17 million |
| Exposure with no netting | +\$20 million | +\$17 million |
| Exposure with netting | +\$3 million | \$0 |

**Close-out** is the immediate closing of all contracts with the defaulted counterparty. When combined with netting of MtM values, an institution may offset what it owes to the counterparty (a negative amount) against what it is owed by the counterparty (a positive amount). If the net amount is negative, the institution will make a payment, but if the net amount is positive, it will make a claim. This results in an immediate realization of net gains or losses for the institution.

**Collateralization** (i.e., margining) occurs in the form of a collateral agreement between two counterparties that reduces exposure by requiring sufficient collateral to be posted by either counterparty to support the net exposure between them. Sufficient collateral does theoretically reduce the net exposure to zero. Posting collateral is done on a periodic basis to minimize transaction costs. However, collateralization does come with market, operational, and legal risks as well as significant work requirements to ensure the process is done properly.

A **walkaway feature** allows a party to cancel the transaction if the counterparty defaults. It is advantageous if a party has a negative MtM and the counterparty defaults.

**Diversification** of counterparty risk limits credit exposure to any given counterparty consistent with the default probability of the counterparty. When an institution trades with more counterparties, there is much less exposure to the failure of any given counterparty.

As described previously, exchanges and centralized clearinghouses take on the role of the counterparty and guarantee all trades by removing all counterparty risk from trades. However, this may simply redistribute counterparty risk as opposed to completely eliminating the risk.

## Mitigating Counterparty Risk

As mentioned, **netting** is commonly used to mitigate counterparty risk. Each party's required payment is computed and then offset so that only the party that "owes" a net amount is required to make that payment to the counterparty. The success of netting depends on the nature of the payments involved and whether they are easy to offset.

A second way to mitigate counterparty risk is the use of **collateralization**. Taking collateral equal to or greater than the notional amount of principal should theoretically eliminate all counterparty risk. However, by taking collateral, there are some administrative costs involved in addition to taking on liquidity risk (i.e., collateral may have to be sold at a significant discount in the short term) and legal risk (i.e., attempting to take title on the collateral may be a long and drawn out legal process).

A third way to mitigate counterparty risk is through **hedging**. Using credit derivatives allows an organization to reduce counterparty exposure to its own clients in exchange for increasing counterparty exposure to clients of a competitor. Therefore, hedging generates market risk.

**Central counterparties** (e.g., exchanges and clearinghouses) frequently take on the role of the counterparty, which offers another way to mitigate counterparty risk. They are a convenient way to centralize counterparty risks, settle transactions, and reduce the bilateral risks inherent in many derivatives contracts. However, the use of central counterparties does reduce the incentive of parties to carefully assess and monitor counterparty risks. Therefore, using central counterparties generates operational, liquidity, and systemic risks.

## Key Concepts

### LO 26.1

Counterparty risk is the risk that a counterparty is unable or unwilling to live up to its contractual obligations. Counterparty risk is different than lending risk because the future value of the contract is highly uncertain; for lending risk, the value is quite certain. In addition, counterparty risk is bilateral, whereas lending risk is unilateral.

### LO 26.2

Securities financing transactions, such as securities borrowing and lending and repos and reverse repos, carry counterparty risk. Over-the-counter (OTC) derivatives such as interest rate swaps, foreign exchange forwards, and credit default swaps also carry counterparty risk.

### LO 26.3

Institutions that take on counterparty risk through trading activities fall into three size categories: large, medium, and small. They vary based on the volume of trades, coverage of asset classes, and their willingness and ability to post collateral.

### LO 26.4

Important terminology relating to counterparty risk includes the following: credit exposure, credit migration, recovery, mark-to-market (MtM), replacement cost, default probability, recovery rate, and loss given default.

### LO 26.5

Methods to manage counterparty risk include the following: trading only with high-quality counterparties, cross-product netting, close-out, collateralization, walkaway features, diversifying counterparty risk, and exchanges and centralized clearing houses.

Netting, collateralization, hedging, and central counterparties are some common ways to mitigate counterparty risk.

## Concept Checkers

1. When considering counterparty credit risk, which of the following financial products has the largest outstanding notional amount in the marketplace?
   A. Credit default swaps.
   B. Foreign exchange forwards.
   C. Interest rate swaps.
   D. Repos and reverse repos.

2. Liz Parker is a junior quantitative analyst who is preparing a report dealing with credit migration. An excerpt of her report contains the following statements:
   I. Future default probability will likely increase over time, especially for periods far into the future.
   II. When computing the default probability of a counterparty under a risk-neutral measure, we need to first determine the actual default probability.

   Which of Parker's statements is (are) correct?
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

3. Ondine Financial, Inc., (Ondine) uses a variety of techniques to manage counterparty risk. It has entered into an interest rate swap with Scarbo, Inc. (Scarbo). Currently, Ondine's position in the swap has a –$1 million mark-to-market value. Based on the information provided, which of the following credit risk mitigation techniques would be most advantageous to Ondine if Scarbo defaults?
   A. Close-out.
   B. Collateralization.
   C. Netting.
   D. Walkaway.

4. Which of the following statements regarding counterparty credit risk is most accurate?
   A. Counterparty risk is unilateral.
   B. Over-the-counter (OTC) derivatives contain less counterparty risk than exchange-traded derivatives because the counterparty is known.
   C. The precise future value of the contract is uncertain, but the counterparties are aware of whether the future value will be positive or negative.
   D. Counterparty risk is typically associated with counterparty default prior to the settlement rather than default during the settlement process.

5. Which of the following methods of mitigating counterparty risk is most likely to generate systemic risk?
   A. Netting
   B. Collateral.
   C. Hedging.
   D. Central counterparties.

## Concept Checker Answers

1. **C** There are two classes of financial products where counterparty risk exists: over-the-counter (OTC) derivatives and securities financing transactions such as repos and reverse repos. OTC derivatives are significantly larger with interest rate swaps comprising the bulk of the market.

2. **D** Future default probability will likely decrease over time, especially for periods far into the future. This is because of the higher likelihood that the default will have already occurred at some earlier point. In computing the default probability of a counterparty under a risk-neutral measure, one needs to compute the theoretical market-implied probability; the actual default probability applies under a real (historical) measure.

3. **D** Because Ondine currently has a negative mark-to-market value and the counterparty is defaulting, Ondine is able to cancel the transaction while it is "losing." Netting and close-out would require Ondine to make a payment because it would owe a net amount of $1 million. Collateralization is not relevant in this scenario.

4. **D** Counterparty risk is a bilateral risk in that both parties are unaware of the eventual value of the contract and they do not know whether they will earn a profit or loss. For exchange-traded derivatives, the counterparty is the exchange, which effectively mitigates counterparty risk. While counterparty default can happen presettlement and during settlement, counterparty risk typically applies to the risk of default prior to settlement.

5. **D** Mitigating counterparty risk often leads to the generation of other types of risk. In the case of central counterparties, systemic risk is created as counterparty risk has been centralized with a limited amount of groups. If one of these groups fails, a substantial shock may be experienced by the financial system as a whole.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Netting, Compression, Resets, and Termination Features

Topic 27

## Exam Focus

In this topic, we further discuss ways to mitigate counterparty risk and credit exposure. Specifically, we will address the different methods of reducing current and potential future credit exposure. These methods include termination features and netting and close-out features. For the exam, understand the advantages and disadvantages of netting and termination features. Also, be able to explain reset agreements, break clauses, walkaway clauses, and trade compression and how they are used.

## ISDA Master Agreement

**LO 27.1: Explain the purpose of an ISDA master agreement.**

The International Swaps and Derivatives Association (ISDA) Master Agreement standardizes over-the-counter (OTC) agreements to reduce legal uncertainty and mitigate credit risk. This is accomplished by creating a framework that specifies OTC agreement terms and conditions related to collateral, netting, and termination events. The Master Agreement can cover multiple transactions by forming a single legal contract with an indefinite term.

## Netting and Close-Out Procedures

**LO 27.2: Summarize netting and close-out procedures (including multilateral netting), explain their advantages and disadvantages, and describe how they fit into the framework of the ISDA master agreement.**

### Netting and Close-Out Between Two Counterparties

Netting, often called set-off, generally refers to combining the cash flows from different contracts with a counterparty into a single net amount. This is referred to as **payment netting**, which acts to reduce settlement risk while enhancing operational efficiency. A related concept is **close-out netting**, which refers to the netting of contract values with a counterparty in the event of the counterparty's default. The concepts of both netting and close-out incorporate two related rights under a single contract: (1) the right to terminate contracts unilaterally (by only one side) under certain conditions (close-out) and (2) the right to offset (net) amounts due at termination into a single sum.

Before we examine close-out closer, it is important to discuss netting in more detail. Netting has enabled an explosive growth in credit exposures and notional values of trades, and it now covers most derivatives transactions. Institutions often have multiple trades with a counterparty, and these trades can constitute hedges whose values move in opposite directions, or they may constitute unwinds where a reverse trade of equal and opposite value has been executed with the same counterparty. Without netting, an entity's exposure of two equal and opposite trades is the positive mark-to-market exposure. For example, if an entity has two equal and opposite trades with a counterparty with mark-to-market values of +10 and –10, without netting the total exposure is +10. This means that if the counterparty defaults, the value of the two trades is not netted, with the surviving entity having to make a settlement under the negative mark-to-market trade, while unable to collect on the positive one. Therefore, without netting, overall exposure is additive as the sum of the positive mark-to-market values. With netting, exposures of trades are not additive, which significantly reduces risk.

Netting has several advantages and disadvantages:

- *Exposure reduction*: By offsetting exposures with parties managing net positions only, netting reduces risk and improves operational efficiency. Nevertheless, netted exposures can be volatile, which may result in difficulty in controlling exposure.
- *Unwinding positions*: If an entity wishes to exit a less liquid OTC trade with one counterparty by entering into an offsetting position with another counterparty, the entity will remove market risk; however, it will be exposed to counterparty and operational risk. Netting removes these risks through executing a reverse position with the initial counterparty, removing both market and counterparty risk. The downside is that the initial counterparty, knowing that the entity is looking to exit a trade, may impose less favorable terms for the offsetting transaction.
- *Multiple positions*: An entity can reduce counterparty risk, obtain favorable trade terms, and reduce collateral requirements by trading multiple positions with the same counterparty.
- *Stability*: Without netting, entities trading with insolvent or troubled counterparties would be motivated to cease trading and terminate existing contracts, exacerbating the financial distress of the counterparty. With netting, this risk is significantly reduced, and an agreement with a troubled counterparty is more achievable.

Netting agreements (specifically close-out netting) are legal agreements that become effective in the event of a counterparty's bankruptcy. As mentioned, netting agreements are often governed by the ISDA Master Agreement, which serves to eliminate legal uncertainties and reduce counterparty risk under a single legal contract with an indefinite term. A single universal agreement also helps avoid problems that may arise from different treatments of bankruptcy in different jurisdictions. For example, ISDA has obtained legal opinions for the Master Agreement in most jurisdictions. Agreements often cover bilateral netting, which is used for OTC derivative and repo transactions, and balance sheet loans and deposits. When no legal agreement exists that allows netting, exposures do not offset each other and are considered additive.

Close-out and netting become advantageous in derivatives transactions following the default of a counterparty when cash flows cease because these rights allow an entity to execute new replacement contracts. It is clear then that close-out arrangements protect the solvent, or surviving, entity. Note that close-out differs from an **acceleration clause**, which allows the creditor to accelerate (i.e., make immediately due) future payments given a credit event,

such as a ratings downgrade. In contrast to acceleration, **close-out clauses** allow all contracts between a solvent and insolvent entity to be terminated, which effectively cancels the contracts and creates a claim for compensation. If the solvent entity has a negative mark-to-market exposure (it owes the insolvent entity), then the full payment is made to the insolvent entity. If the mark-to-market exposure is positive, the solvent entity becomes a creditor for that amount and can terminate and replace the contracts with another entity.

Both acceleration and close-out clauses have been criticized for making a debtor's refinancing more difficult. Both clauses cause payment amounts to be immediately due and may speed up the financial distress of the insolvent entity. For this reason, courts may impose a stay (temporary suspension) on the agreements to allow for a short period of "time out" while maintaining the validity of the termination clauses.

Despite these criticisms, close-out clauses can be very advantageous to parties. Close-out limits the uncertainty in the value of an entity's position with an insolvent counterparty. Without close-out, an entity would have difficulty estimating to what degree positions offset each other because recovery of exposure is not known. With close-out, however, the solvent entity can fully re-hedge transactions with the insolvent entity while waiting to receive a claim. As a result, although the solvent entity may experience some risk loss, it would minimize market risk and trading uncertainty. In addition, close-out allows entities to freeze their exposures. Because these exposure amounts are known and will not fluctuate, the solvent entity can then better hedge this exposure.

### Netting and Close-Out Between Multiple Counterparties

Up until this point, we have been discussing **bilateral netting**; that is, netting arrangements between two entities. Bilateral netting is important in reducing credit exposure; however, it is limited to two entities only. In reality, trades are often structured in a way where an entity trades with multiple counterparties (known as **multilateral netting**). For example, entity A can have exposure to B, entity B has the same exposure to entity C, and entity C has an identical exposure to entity A. The default of any of these entities would give rise to questions on how to allocate losses.

Under multilateral netting, netting arrangements would involve multiple counterparties to mitigate counterparty and operational risk. Typically, multilateral netting is achieved with a central entity, such as an exchange or clearinghouse, handling the netting process, including valuation, settlement, and collateralization. A disadvantage, however, is that this type of netting arrangement mutualizes counterparty risk and results in less incentive for entities to monitor each other's credit qualities. In addition, multilateral netting can enable redundant trading positions to accumulate in the system, resulting in higher operational costs (this risk is reduced by firms that use algorithms to detect and reduce redundant positions). Finally, multilateral netting requires trading disclosure, which may be disadvantageous to firms wishing to keep proprietary information confidential.

## Netting Effectiveness

**LO 27.3: Describe the effectiveness of netting in reducing credit exposure under various scenarios.**

As we have previously discussed, netting can either reduce exposure to a counterparty or have no effect on exposure, but it can never increase it. We now look at netting in more detail, including the relationship between netting and exposure.

A trading instrument will have a beneficial effect on netting if it can have a negative mark-to-market (MtM) value during its life. For instruments whose MtM value can only be positive during their life, the effect on netting will not be as beneficial. Instruments with only positive MtM values include options with up-front premiums such as equity options, as well as swaptions, caps and floors, and FX options. Other instruments can have negative MtM value during their life; however, there is a greater likelihood that MtM will be positive. These instruments include long options without up-front premiums, certain interest rate swaps, certain FX forwards, cross-currency swaps, off-market instruments, and wrong-way instruments.

Despite these instruments having either only positive or mostly positive MtM values, it may still be worthwhile for an entity to include them under a netting agreement for the following reasons:

- Future trades with negative MtM values could offset the positive MtM of these instruments.
- Inclusion of all trades is necessary for effective collateralization.
- Netting is beneficial as it ensures that if these positions need to be unwound in the future and an offsetting (mirror) trade is required, there will be no residual counterparty risk.

## Termination Features

**LO 27.4: Describe the mechanics of termination provisions and explain their advantages and disadvantages.**

Termination events allow institutions to terminate a trade before their counterparties become bankrupt. A **reset agreement** readjusts parameters for trades that are heavily in the money by resetting the trade to be at the money. Reset dates are typically linked with payment dates, but they could also be triggered after a certain market value is breached. As an example, consider a resettable cross-currency swap. With this trade, the MtM value of the swap is exchanged at each reset date. In addition, the foreign exchange rate, which influences the swap's MtM value, is reset to the current spot rate. This reset will end up changing the notional amount for one leg of the swap.

**Additional termination events** (ATEs), which are sometimes referred to as break clauses, are another form of a termination event, which allow an institution to terminate a trade if the creditworthiness of their counterparty declines to the point of bankruptcy. More specifically, a **break clause** (also called a liquidity put or early termination option) allows a party to terminate a transaction at specified future dates at its replacement value. Break clauses are often bilateral, allowing either party to terminate a transaction, and are useful in providing

an option to terminate transactions—particularly long-dated trades—without cost when the quality of the counterparty declines. Events to trigger a break clause generally fall into three categories:

- Mandatory. The transaction will terminate at the date of the break clause.
- Optional. One or both counterparties have the option to terminate the transaction at the pre-specified date.
- Trigger-based. A trigger, like a ratings downgrade, must occur before the break clause may be exercised.

Despite their advantages, break clauses have not been highly popular. One explanation is that break clauses, in effect, represent a discrete form of collateralization; however, collateralization can be better achieved by the continuous posting of collateral. Another explanation is known as "banker's paradox," which implies that for a break clause to be truly useful, it should be exercised early on, prior to the substantial decline in a counterparty's credit quality. Entities, however, typically avoid early exercise to preserve their good relationships with counterparties.

**Walkaway clauses** allow an entity to benefit from the default of a counterparty. Specifically, under these clauses an entity can walk away from, or avoid, its net liabilities to a counterparty that is in default, while still being able to claim in the event of a positive MtM exposure. Walkaway clauses were popular prior to 1992, but they have been less common since the 1992 ISDA Master Agreement. They have also been criticized for creating additional costs for a counterparty in the event of a default, for creating moral hazard, and, because a walkaway feature may already be priced in a transaction, hiding some of the risks in a transaction. For these reasons, these clauses should be ultimately avoided.

As mentioned previously, multilateral netting is achieved with a central entity, such as an exchange or clearinghouse, handling the netting process, including valuation, settlement, and collateralization. An approach for utilizing multilateral netting without the need for a membership organization is **trade compression.** Because portfolios often have redundancies among trades with multiple counterparties, compression aims to reduce the gross notional amount and the number of trades (e.g., OTC derivatives transactions). Thus, trade compression can reduce net exposure without the need to change an institution's overall risk profile.

Trade compression requires participants to submit applicable trades for compression along with their desired risk tolerance. The submitted trades are then matched to each counterparty and netted into a single contract. For example, consider an institution with three credit default swap (CDS) contracts for the same reference entity and maturity, but with different counterparties. In this case, the three trades can be compressed into a single net contract by netting out the long and short contracts and using the weighted average of the three contract coupons as the net contract coupon. Trade compression services, such as TriOptima, help reduce OTC derivatives exposures for various credit derivatives. In addition, recent changes to the CDS market, such as standard coupons and maturity dates, also help promote the benefits of trade compression.

## Key Concepts

### LO 27.1

Standardization of terms of OTC derivatives through the ISDA Master Agreement is a key way to mitigate credit risk to improve liquidity and reduce transaction costs.

### LO 27.2

Netting involves combining the cash flows from different contracts with a counterparty into a single net amount (payment netting). Close-out netting refers to netting contract values with a counterparty if the counterparty defaults. Without netting, exposures are additive; with netting, exposures of trades are not additive.

Bilateral netting is limited to two entities only. Multilateral netting involves netting between multiple parties, usually with a central entity, such as an exchange or clearinghouse, handling the netting process.

### LO 27.3

Netting arrangements are beneficial as long as trading instruments can have negative mark-to-market (MtM) values during their life. Netting for trades with the possibility of only positive exposures is generally not beneficial, although benefits can arise if future trades with negative MtM values could offset the positive MtM of these instruments.

### LO 27.4

Termination events allow institutions to terminate a trade before their counterparties become bankrupt. A break clause allows a party to terminate a trade at specified future dates at replacement values. Walkaway clauses allow an entity to walk away from its liabilities to a counterparty that is in default, while still being able to make a claim on its own exposure. Trade compression reduces net exposure without the need to change the overall risk profile.

## Concept Checkers

1. Riggs Resources, LLC, (Riggs) is a commodity trading firm. Riggs has numerous trades outstanding with several counterparties; however, it is concerned with presettlement risk. In order to reduce presettlement risk (the risk that Riggs's counterparties would default before settlement), it would be most beneficial for Riggs to:
   A. have payment netting.
   B. have close-out netting.
   C. analyze potential losses as the sum of exposures.
   D. have netting but not set-off.

2. Entity XYZ is netting its trades with Entity ABC. Which of the following techniques best describe this type of netting arrangement?
   A. Multilateral netting.
   B. Bilateral netting.
   C. Close-out netting.
   D. Additive exposure netting.

3. Assume the following current MtM values for five different transactions for Entity ABC: +5, –4, +2, +3, and –6. What is the total exposure with and without netting, respectively?
   A. 0, 10.
   B. 20, 10.
   C. 10, 0.
   D. 10, 20.

4. Which of the following trading instruments would have the most beneficial effect on netting?
   A. Options with up-front premiums.
   B. Equity options.
   C. FX options.
   D. Futures.

5. Leverage, Inc., an investment bank, has numerous credit default swaps with XYZ Corp. Leverage has established a break clause with XYZ Corp. to reduce risk. The break clause is trigger-based and may be exercised once the trigger is satisfied. The CEO of Leverage is concerned about a banker's paradox. Which of the following statements best describe the CEO's concern?
   A. To be effective, the break clause option should not be used too early.
   B. The weak firm often recovers after the use of the break clause.
   C. The break clause option is used too late, and the weak firm gets weaker.
   D. The break clause option is used too early, and relations with the counterparty suffer.

## Concept Checker Answers

1. **B** To minimize presettlement risk, Riggs should have close-out netting. Under close-out, contracts between solvent and insolvent counterparties are terminated and netted.

   Payment netting would reduce settlement and operational risk, but not presettlement risk. Netting also means individual positive exposures are nonadditive. The terms netting and set-off are synonymous.

2. **B** Bilateral netting is a netting arrangement between two entities and is limited to two entities. Trades with multiple counterparties is known as multilateral netting. Close-out netting refers to netting contract values with a counterparty if the counterparty defaults.

3. **A** The total exposure with netting is 0 (5 – 4 + 2 + 3 – 6 = 0), and the total exposure without netting is 10 (5 + 2 + 3 = 10).

4. **D** A trading instrument will have a beneficial effect on netting if it can have a negative mark-to-market (MtM) value during its life. For instruments whose MtM value can only be positive during their life, the effect on netting will not be as beneficial. Instruments with only positive MtM values include options with up-front premiums such as equity options, as well as swaptions, caps and floors, and FX options. Futures can have negative MtM values.

5. **C** A break clause (also called a liquidity put or early termination option) allows a party to terminate a transaction at specified future dates at its replacement value. Despite their advantages, break clauses have not been highly popular. One explanation is known as banker's paradox, which implies that for a break clause to be truly useful, it should be exercised early on, prior to the substantial decline in a counterparty's credit quality. Entities, however, typically avoid early exercise to preserve their good relationships with counterparties.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Collateral

Topic 28

## Exam Focus

This topic examines collateral and introduces the types of collateral, the features of a collateralization agreement and a credit support annex (one-way and two-way), and the reconciliation of collateral disputes. For the exam, be familiar with the key parameters associated with collateral (e.g., threshold, independent amount, and minimum transfer amount). In addition, understand the risks associated with collateralization, focusing on market risk, operational risk, and funding liquidity risk.

## Credit Support Annex

### LO 28.1: Describe features of a credit support annex (CSA) within the ISDA Master Agreement.

The concept behind collateralization is straightforward. When two parties execute certain trades (e.g., OTC forwards, swaps), one will have a negative MtM (mark-to-market) exposure, and the other party will have a positive MtM exposure at any given time. The party with the negative exposure will then post collateral in the form of cash or securities to the party with the positive exposure. In essence, *collateral is an asset supporting a risk in a legally enforceable way*. Collateral management is often bilateral, where either side to a transaction is required to post or return collateral to the side with the positive exposure.

Firms can manage credit exposures and mitigate counterparty credit risk by either limiting the notional value of trades with counterparties or offsetting trades that limit exposure though netting. There are essentially four motivations for managing collateral: (1) reduce credit exposure to enable more trading, (2) have the ability to trade with a counterparty (e.g., restrictions on credit ratings may preclude an entity from trading on an uncollateralized basis), (3) reduce capital requirements, and (4) allow for more competitive pricing of counterparty risk.

Collateral management has evolved over the last few decades from having no legal standards to being highly standardized through the introduction of ISDA documentation in 1994. The purpose of a **credit support annex** (CSA) incorporated into an ISDA Master Agreement is to allow the parties to the agreement to mitigate credit risk through the posting of collateral. Because collateral can vary greatly in terms of amount, liquidity, and risk levels (as well as many other elements), a CSA is created to govern issues such as collateral eligibility, interest rate payments, timing and mechanics associated with transfers, posted collateral calculations, haircuts to collateral securities (if applicable), substitutions of collateral, timing and methods for valuation, reuse of collateral, handling disputes, and collateral changes that may be triggered by various events. In order to work as intended,

CSAs must define all collateralization parameters (discussed in the following) and account for any scenarios that may impact both the counterparties and the collateral they are posting.

There are three key parameters established with any CSA (and collateralized agreements in general). These parameters include the following:

- **Threshold.** Collateral will be posted when the level of MtM exceeds this threshold level.
- **Minimum transfer amount**. This represents the minimum amount of collateral that can be called at a given time.
- **Independent amount**. Not often used in CSAs currently, but represents the amount of extra collateral that is required independent of the level of exposure.

## Valuation Agents

### LO 28.2: Describe the role of a valuation agent.

The valuation agent is responsible for calling for the delivery of collateral and handles all calculations. The valuation agent's role is to calculate (1) credit exposure, (2) market values, (3) credit support amounts, and (4) the delivery or return of collateral. Larger entities often insist on being valuation agents when dealing with smaller counterparties. When the size difference between counterparties is small, both counterparties may be valuation agents. In this case, each entity would call for collateral when they have positive exposure; however, this could lead to disputes and delays in processing collateral movements. One remedy is to use a third-party valuation agent that would handle the collateral process, processing collateral substitutions, resolving disputes, and producing daily valuation reports.

## Collateral Agreements and Types of Collateral

### LO 28.3: Describe types of collateral that are typically used.

The process of collateralization is typically done through legal documents under which parties negotiate collateral supporting documents that state the terms and conditions of the process. Collateral agreements should quantify parameters and specify the currency, type of agreement (one-way or two-way), what collateral is eligible, timing regarding delivery and margin call frequency, and interest rates for cash collateral. Trades between counterparties are then marked-to-market (MtM) on an ongoing basis (typically daily), and valuations including netting are determined. The party with the negative MtM exposure then delivers collateral to the other side of the transaction, and the collateral position is updated.

There are many types of collateral used, depending on the riskiness of the credit exposures. Collateral can include cash, government and government agency securities, mortgage-backed securities, corporate bonds and commercial paper, letters of credit, and equity. The most common type of collateral is cash; however, during extreme market events, the supply of cash collateral can be limited. Other collateral types, including agency securities, are often preferred for liquidity; however, recent market events have led to questioning the true riskiness of these securities. In addition, noncash collateral may give rise to problems with rehypothecation (defined later) and create price uncertainty.

## Collateral Coverage, Disputes, and Resolutions

### LO 28.4: Explain the process for the reconciliation of collateral disputes.

To mitigate risk, it is generally preferred to include the maximum number of trades in collateral agreements. However, if even a single trade cannot be properly valued, it can complicate collateral calls and may lead to collateral disputes. If trades include potentially problematic assets, it may be optimal to only focus on a subset of trades that make up the majority of credit exposure and leave out asset classes that are hard to value either due to complexity (e.g., exotic options) or illiquidity (e.g., credit derivatives). Global considerations are also important, especially as counterparties trade with each other over many time zones and geographical locations. It may be optimal to handle trades separately with regions that are problematic and make up only a small portion of trades. Finally, if an entity expects one of its counterparties to have difficulty valuing certain trades or assets, it may be preferred to leave those trades uncollateralized rather than face potential and frequent disputes. Given that collateral agreements typically require that undisputed amounts be transferred immediately, it is generally advantageous to collateralize the majority of products.

If disputes do arise, they can relate to the trade population, trade valuation, netting rules, market data and market closing time, and valuing collateral that was previously posted. If the disputed amount or valuation difference is small, counterparties may simply split the difference. If the disputes involve larger differences, the exposure will remain uncollateralized until the dispute is resolved. Disputes include the following steps: (1) the disputing party notifies the counterparty of its intent to dispute the exposure by the end of the day following the collateral call; (2) all undisputed amounts are transferred, and the reason for the dispute is identified; and (3) for unresolved disputes, the parties will request quotes from several market makers (usually four) for the MtM value.

Reconciling trades minimizes the chance of disputes. Parties may also find it beneficial to perform dummy (practice) reconciliations prior to trading and periodic reconciliations during trading (weekly or monthly) to preempt future disputes.

## Collateralization Agreement Features

### LO 28.5: Explain the features of a collateralization agreement.

Collateral agreements are typically negotiated prior to any trading, and they are often updated prior to an increase in trading. Parameters must be clearly defined, and parties must balance the work involved in calling and returning collateral with the benefits of risk mitigation.

Terms of a collateral agreement may be linked to the credit quality of counterparties in order to minimize operational workload while maintaining the ability to tighten collateral terms when a party's credit quality declines. Counterparties most commonly link a tightening of collateral terms to changes in credit rating (e.g., to a downgrade in rating to below investment grade). While this approach is easy to set up, it can lead to issues by requiring the downgraded counterparty to post collateral exactly at a time when it is

experiencing credit issues. This can lead to a "death spiral" of the affected counterparty, as the counterparty faces multiple collateral calls. As a result, it may be preferable to link collateral terms not to the credit rating of entities, but to credit spreads, the market value of equity, or net asset values.

Margin calls should be done at least daily. Products like repos and swaps that are cleared via central counterparties most often have intraday margining. While longer margin frequencies likely reduce operational workloads, daily margining has, more or less, become the market norm.

**Threshold** in margining refers to the level of exposure below which collateral will not be called. As a result, threshold represents the level of uncollateralized exposure, and only the incremental amount above the threshold would be collateralized. Thresholds generally aim to reduce the operational burden of calling collateral too frequently. A threshold of zero means any exposure is collateralized, while a threshold of infinity means all exposure is uncollateralized. Thresholds are most often linked to credit ratings in a tiered manner, with lower credit ratings corresponding to lower or zero threshold amounts.

**Independent amount**, or initial margin, is the collateral amount that is posted upfront and is "independent" of any subsequent collateralization and is often used to mitigate the widening of credit spreads or declines in equity values. An independent amount is typically required by stronger credit quality counterparties or by the counterparty more likely to have positive exposures and represents a level of **overcollateralization**. Independent amounts are also typically linked to the credit rating of counterparties in a tiered manner; however, as opposed to thresholds, the level of independent amount *increases* with lower ratings. Independent amounts can be thought of as converting counterparty risk into gap risk, ensuring that the less risky counterparty always remains overcollateralized by this amount without incurring losses, even when the risky counterparty defaults. Independent amounts should, therefore, be large enough to minimize the gap from large value movements of trades should the risky counterparty default.

A **minimum transfer amount** represents the smallest amount of collateral that can be transferred. A minimum transfer amount is used to reduce the operational workload of frequent transfers for small amounts of collateral, which must be balanced against the benefits of risk mitigation. It is important to note that the threshold and minimum transfer amount are additive; that is, exposure must exceed the sum of *both* before a collateral call can be made. Minimum transfer amounts are also typically tied to credit ratings, with higher ratings corresponding to higher amounts.

Collateral amounts typically use **rounding** (e.g., to the nearest thousand) to avoid transferring very small amounts during collateral calls or returns.

A **haircut** is essentially a discount to the value of posted collateral. In other words, a haircut of x% means that for every unit of collateral posted, only (1 – x)% of credit will be given. This credit is also referred to as valuation percentage. Cash typically has a haircut of 0% and a valuation of 100%, while riskier securities have higher haircut percentages and lower corresponding valuation percentages.

For example, if a particular sovereign bond has a haircut of 2% and a collateral call of $100,000 is made, only 98% of the collateral's value is credited for collateral purposes. That

is, in order to satisfy a $100,000 collateral call, $102,041 ($100,000 / 0.98) of the sovereign bond must be posted (or $100,000 in cash).

It is easy to see that riskier securities have greater haircuts to account for their volatility, which may lead to a decline in their value. In the order of increasing riskiness and higher haircuts, cash typically has no haircuts, followed by high-quality government bonds, triple-A rated corporate bonds, structured notes or products, and, finally, equities and commodities. Key factors to consider when assessing haircuts are time to liquidate collateral, volatility of the collateral's underlying market, and the default risk, maturity, and liquidity of the security. Assessing haircuts will often depend on current market conditions using sophisticated value at risk (VaR) calculations.

Entities usually pay interest, coupons, dividends, and other cash flows to counterparties posting collateral as long as the counterparty is not in default. Interest on cash collateral is paid at an overnight market rate. During times of high volatility and illiquid markets, cash collateral is generally preferred, and entities may pay higher-than-market interest rates as an incentive to the entity posting collateral.

We will now look at substitution, reuse, and rehypothecation of collateral. Counterparties sometimes require that the original posted collateral be returned to them for various reasons, including meeting certain delivery commitments. In this case, they can make a **substitution** request by posting an equivalent value of some other eligible collateral. Substitution requests cannot be refused by the other party if the substituted collateral meets all eligibility criteria. Noncash collateral may also be sold, used in repo transactions, or rehypothecated.

**Rehypothecation** refers to transferring posted collateral to other counterparties as collateral. While widespread, rehypothecation carries two related risks. Consider a scenario where party A pledges collateral to party B; party B rehypothecates this collateral to party C. If party C defaults, then party B will not only have a loss from not receiving the collateral from party C, it will also have a liability to party A for not returning its collateral. The practice of rehypothecation was relatively widespread prior to the 2007–08 credit crisis; however, it has been significantly less popular following the crisis. Parties now increasingly prefer cash collateral.

## CSA Agreements

**LO 28.6: Differentiate between a two-way and one-way CSA agreement and describe how collateral parameters can be linked to credit quality.**

There may be instances when CSAs are not used. Institutions may be unable or unwilling to post collateral. This may be because their credit quality is far superior to their counterparty or they cannot commit to the operational and liquidity requirements that arise from committing to a CSA.

A **two-way CSA** is often established when two counterparties are relatively similar, as it will be beneficial to both parties involved. It is important to note that the two sides may not be treated equally, as certain key parameters (like threshold and independent amounts) may differ depending on the respective risk levels of each party.

A **one-way CSA** differs from a two-way CSA in that the former only requires that one counterparty post collateral (either immediately or after a specific event, such as a ratings downgrade). As a result, the CSA will be beneficial to the receiver of the collateral and at the same time will present additional risk for the counterparty posting the collateral. These types of CSAs are established when two counterparties are significantly different in size, risk levels, et cetera.

The terms of a collateral agreement are usually linked to the credit quality of the counterparties in a transaction. This is beneficial when a counterparty's credit quality is strong because it minimizes operational workload. However, it is also beneficial when a counterparty's credit quality is weak as it allows the other party to enforce collateralization terms triggered by a quality downgrade. Although credit ratings are the most common quality linked, others include market value of equity, net asset value, and traded credit spread. The benefits of linking to credit ratings must be weighed against the costs associated with the requirement of collateral when a ratings downgrade occurs.

## Collateral Agreement Risks

**LO 28.7: Explain how market risk, operational risk, and liquidity risk (including funding liquidity risk) can arise through collateralization.**

Collateralization may improve asset recovery in the event of a counterparty default, but it should be viewed as a supplement to, not a replacement for, ongoing due diligence review of credit quality and exposure. Use of collateral may be viewed as a double-edged sword. When managed properly, it can mitigate risks, but when managed poorly, it may well give rise to additional risks. Collateral agreements could potentially cause the following risks.

### Market Risk

Market risk relates to the degree of market movements that have occurred since the last posting of collateral. It is relatively small compared to the risk of an uncollateralized situation, but market risk is a challenge to hedge and to quantify.

Even though collateral is in place to mitigate counterparty risk, there will always be some residual risk due to parameters such as minimum transfer amounts and thresholds that delay the collateral process. In addition, even when collateral is called, there will be a normal delay in sending/receiving the collateral. This delay is represented as the margin period of risk, which is the effective time between a collateral call and the receipt of the collateral.

### Operational Risk

Potential pitfalls in the handling of collateral include missed collateral calls, failed deliveries, computer error, human error, and fraud. Proper controls must be in place to reduce the likelihood of the occurrence of any one of the foregoing items. Examples of proper controls would be the existence of accurate and enforceable legal agreements, robust IT systems capable of automating many steps in the process, timely and accurate valuation of the collateral, current information on independent amounts, minimum transfer amounts,

rounding, a requirement that collateral types and currencies must be available for each counterparty, and careful observation of the failure to deliver collateral.

### Liquidity and Liquidation Risk

Transaction costs may result when having to liquidate collateral to mitigate counterparty risk. These are often in the form of a bid-ask spread or selling costs. Liquidating a security in an amount that is large relative to its typical trading volume may negatively impact its price, leading to a substantial loss. The alternative is to liquidate a position slowly. With this approach, the counterparty is exposed to market volatility during the period of liquidation. Additional considerations regarding liquidity risk include:

- How large is the market capitalization of the issue posted as collateral?
- Is there a link between the value of the collateral and the counterparty's credit quality? This would be an example of wrong-way risk (when credit exposure and default risk both increase at the same time).
- Would the liquidity of the collateral change due to a default by the counterparty?

### Funding Liquidity Risk

Funding liquidity risk refers to the ability of an institution to settle its obligations quickly when they become due, which results from the funding needs established in a CSA. For various reasons, collateral agreements are not in place for many OTC derivatives transactions. When a counterparty does not have the operational capacity or liquidity to handle frequent collateral calls (required under a CSA), the counterparty will be vulnerable to funding implications. This risk is relatively small when markets are liquid and funding costs are low. However, when markets are illiquid, the risks become higher because funding costs can increase considerably.

### Default Risk

The default of a security posted as collateral will lower its value (when the loss in value is unlikely to be covered by a haircut). Cash or high-quality fixed-income securities are usually the preferred type of collateral. Should the collateral's credit rating fall below what the collateral agreement specifies, then it would need to be replaced. Poor collateral may fail to mitigate counterparty risk.

### Foreign Exchange Risk

Foreign exchange risk occurs when counterparties have different currencies. Collateral carrying foreign exchange risk can be hedged in spot and forward markets. The process must be done carefully due to the dynamic and changing value of the collateral.

# Key Concepts

## LO 28.1

A credit support annex (CSA) allows parties to mitigate credit risk through the posting of collateral. The CSA provides governance on many issues related to the collateral itself, including what may be used, when and how it should be valued and transferred, and any changes that must be made upon the occurrence of certain events. A CSA will also define key parameters such as the threshold, minimum transfer amount, and independent amount.

## LO 28.2

The role of the valuation agent is to call for the delivery of collateral and handle any collateral-related calculations, including credit exposure, market values, credit support amounts, and the delivery/return of collateral. One or both parties to an agreement may be the valuation agent, or alternatively, a third party agent may be used.

## LO 28.3

Collateralization involves the party with the negative exposure posting collateral in the form of cash or securities to the party with the positive exposure. Collateral can include cash, government and government agency securities, mortgage-backed securities, corporate bonds and commercial paper, letters of credit, and equity. The most common type of collateral is cash.

## LO 28.4

Collateral disputes may arise due to the valuation and population of trades, market data and market closing time, netting rules, and valuing collateral previously posted. Managing disputes include the following steps: (1) the disputing party notifies the counterparty of its intent to dispute the exposure by the end of the day following the collateral call; (2) all undisputed amounts are transferred and the reason for the dispute is identified; and (3) for unresolved disputes, the parties will request quotes from several market makers (usually four) for the MtM value. Reconciling trades on a regular basis can minimize potential disputes.

## LO 28.5

Threshold is the level of exposure below which collateral will not be called and represents the level of uncollateralized exposure.

Independent amount, or initial margin, is the collateral amount that is posted upfront and is independent of any subsequent collateralization. It represents a level of overcollateralization and can be thought of as converting counterparty risk into gap risk to always maintain an overcollateralized position by the stronger credit quality party.

A minimum transfer amount represents the smallest amount of collateral that can be transferred and is used to reduce operational workload. The threshold and minimum transfer amounts are additive.

A haircut is a discount to the value of posted collateral, with cash having the lowest discount (highest credit given). The riskier the security, the higher the haircut and the lower the credit given.

Substitution refers to posting an equivalent value of other eligible collateral. Rehypothecation refers to transferring posted collateral to other counterparties as collateral.

## LO 28.6

A one-way CSA requires one counterparty to post collateral, while a two-way CSA requires both sides to post collateral. For a two-way CSA, certain key parameters may differ if the parties' have different risk levels.

Collateral agreements are often linked to the credit quality of the counterparties in a transaction, in particular credit ratings. While this linking can be beneficial to one party if the other party's credit rating declines, there are costs associated with requiring collateral when a ratings downgrade occurs.

## LO 28.7

Key risks involved as a result of entering into a collateral agreement include the following: market risk (unfavorable market movements since the last collateral posting), operational risk (operational issues in the handling of collateral transactions), liquidity and liquidation risk (the ability to liquidate collateral without an unexpected or substantial loss in value), and funding liquidity risk (the ability to meet funding obligations as they come due).

## Concept Checkers

1. Which of the following features is least likely a benefit of collateralization?
   A. Reduces capital requirements.
   B. Allows for more competitive pricing of counterparty risk.
   C. Reduces market, operational, and liquidity risk.
   D. Reduces credit exposure.

2. Collateral agreements could potentially create multiple risks, including liquidity and liquidation risks. Which of the following is most accurate regarding liquidity and liquidation risk?
   A. Liquidation risk occurs when the amount of a security sold is large relative to its outstanding volume, which may affect the price of that security.
   B. Liquidity risk must be hedged in spot and forward markets.
   C. Liquidation risk embodies a transaction cost when collateral is liquidated in accordance with an independent amount.
   D. Liquidity risk occurs when there are potential pitfalls in the handling of collateral, including human error.

3. When dealing with a hedge fund, a bank would most likely negotiate a(n):
   A. one-way agreement in the bank's favor given the bank's stronger credit rating.
   B. one-way agreement in the bank's favor agreeing to post collateral to the hedge fund.
   C. two-way agreement given the relatively small difference in credit quality between the two entities.
   D. two-way agreement where both parties agree to post collateral.

4. Assume a sovereign bond has a haircut of 5% and is used for a collateral call of \$100,000. What amount is credited if a \$100,000 bond is submitted, and what amount of bond is needed for \$100,000 to be credited, respectively?
   A. \$100,000; \$106,263.
   B. \$95,000; \$100,000.
   C. \$95,000; \$105,263.
   D. \$105,263; \$95,000.

5. Which of the following statements is least accurate regarding a credit support annex (CSA) and/or an ISDA Master Agreement?
   A. ISDA Master Agreements help standardize collateral management.
   B. CSAs must define all collateralization parameters in order to work as intended.
   C. Compared to the ISDA Master Agreement, CSAs were first to establish collateral standards.
   D. CSAs are incorporated into an ISDA Master Agreement.

## Concept Checker Answers

1. **C** Collateralizing trades reduces credit exposure (credit risk) and capital requirements, and allows for more competitive pricing of counterparty risk. However, collateralization also creates other risks including market risk (negative equity leaving exposures partially or fully uncollateralized), operational risk (legal obstacles to take possession of collateral), and liquidity risk (difficulty in selling collateral at a fair market value).

2. **A** Liquidating a security in an amount that is large relative to its typical trading volume may negatively impact its price, leading to a substantial loss.

3. **A** The bank would most likely negotiate a one-way agreement in its own favor given the higher credit quality of the bank. This type of negotiation is typical when there are large differences in credit quality between two entities.

4. **C** A haircut is essentially a discount to the value of posted collateral. In other words, a haircut of x% means that for every unit of collateral posted, only (1 – x)% of credit will be given. This credit is also referred to as valuation percentage. If a particular sovereign bond has a haircut of 5% and a collateral call of $100,000 is made, only 95% of the collateral's value is credited for collateral purposes. That is, in order to satisfy a $100,000 collateral call, $105,263 ($100,000 / 0.95) of the sovereign bond must be posted.

5. **C** The purpose of a credit support annex (CSA) incorporated into an ISDA Master Agreement is to allow the parties to the agreement to mitigate credit risk through the posting of collateral. A CSA is created to govern issues such as collateral eligibility, interest rate payments, timing and mechanics associated with transfers, posted collateral calculations, haircuts to collateral securities (if applicable), substitutions of collateral, timing and methods for valuation, reuse of collateral, handling disputes, and collateral changes that may be triggered by various events. In order to work as they are intended to work, CSAs must define all collateralization parameters and account for any scenarios that may impact both the counterparties and the collateral they are posting.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Credit Exposure

Topic 29

## Exam Focus

In this topic, we describe credit exposures for various security positions. For the exam, understand credit exposure metrics and their application. Be prepared to identify potential future exposure (PFE) for the various asset classes discussed. Understand how credit exposure and VaR methods compare, and be able to explain credit exposure factors. Know how payment frequencies and exercise dates impact exposure profiles. Also, be familiar with netting tables and be able to calculate the netting factor. Understand the impact of collateral attributes on credit exposure reduction and know the steps in the remargin period. Finally, be able to explain the difference between risk-neutral and real-world parameters in arbitrage models and risk management applications.

## Credit Exposure Metrics

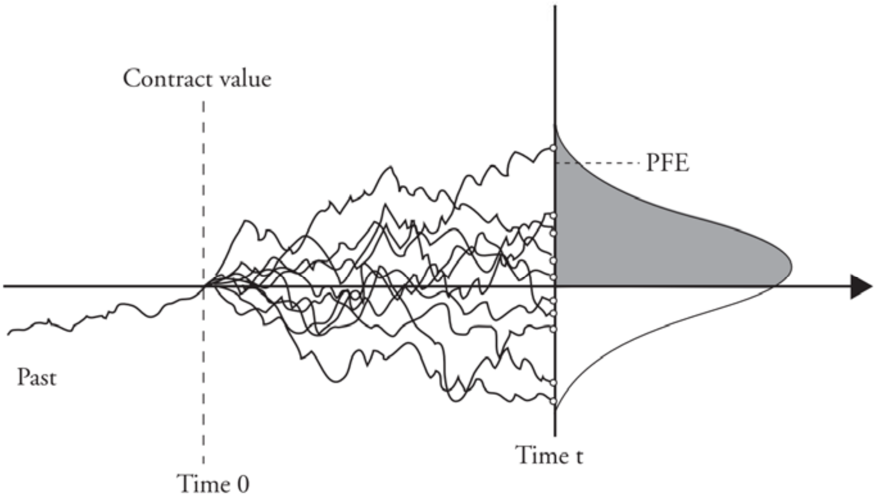
**LO 29.1: Describe and calculate the following metrics for credit exposure: expected mark-to-market, expected exposure, potential future exposure, expected positive exposure and negative exposure, effective exposure, and maximum exposure.**

**Expected mark to market** (MtM) is the expected value of a transaction at a given point in the future. Long measurement periods as well as the specifics of cash flows may cause large differences between current MtM and expected MtM.

**Expected exposure** (EE) is the amount that is expected to be lost if there is positive MtM and the counterparty defaults. Expected exposure is larger than expected MtM because the latter considers both positive and negative MtM values.

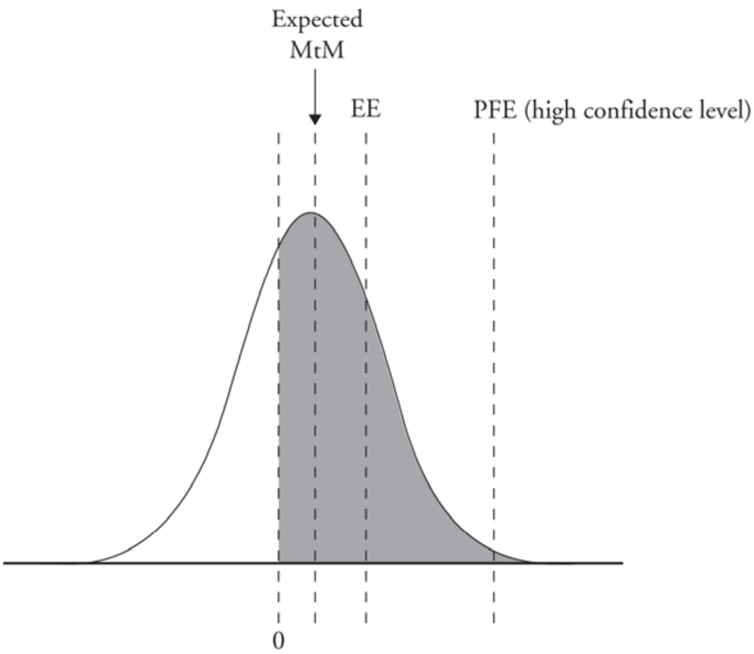
**Potential future exposure** (PFE) is an estimate of MtM value at a specific point in the future. It is usually based on a high confidence level, taking into account the worst-case scenario. The current MtM may follow a number of different possible paths into the future, so a probability distribution of PFE can be derived, similar to the one shown in Figure 1. Positive MtM (the shaded area in Figure 1) is the part of the exposure that is at risk. Any points in this shaded area can represent PFE.

**Figure 1: Potential Future Exposure**



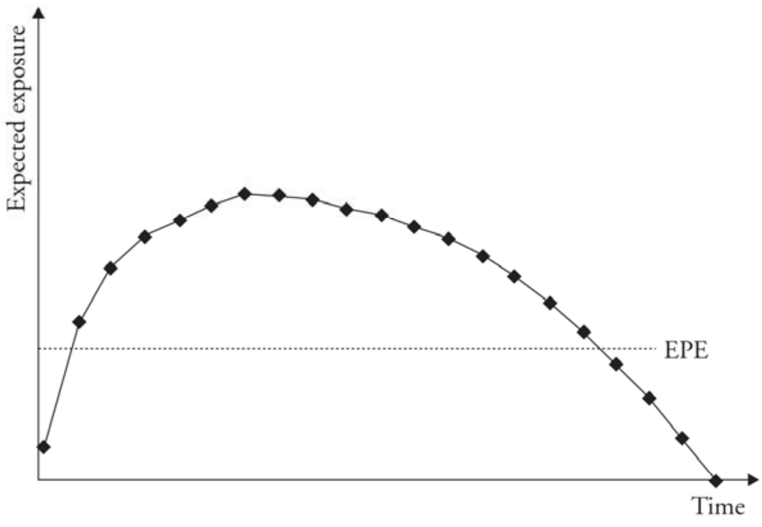

In other words, PFE is the worst exposure that could occur at a given time in the future at a given confidence level. Potential future exposure represents a "gain" amount because it is the amount at risk if the counterparty defaults. **Maximum PFE** is the highest PFE value over a stated time frame.

**Figure 2: Credit Exposures**




**Expected positive exposure** (EPE) is the average EE through time. Expected positive exposure is a useful single amount to quantify exposure.

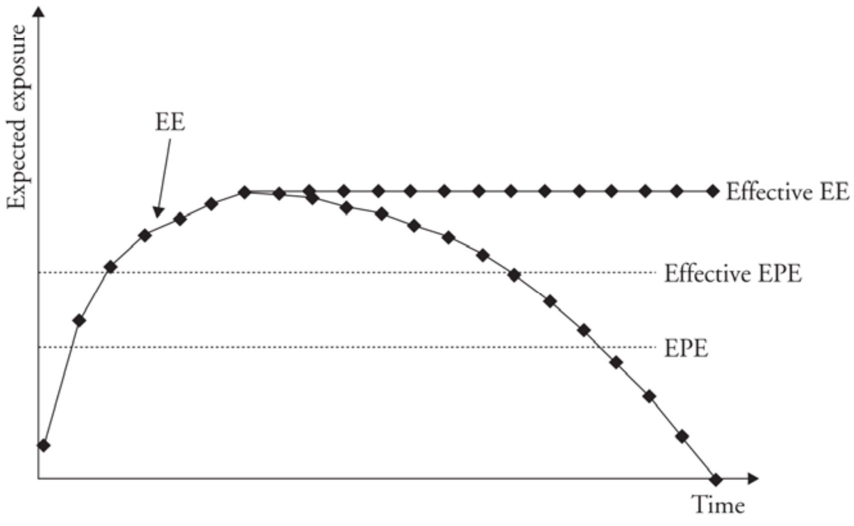
**Figure 3: Expected Positive Exposure**




**Negative exposure**, which is the exposure from the counterparty's point of view, is represented by negative future values. The expected negative exposure (ENE) and the negative expected exposure (NEE) are the exact opposite of EPE and EE.

The **effective EE** and **effective EPE** measures are meant to properly capture rollover risk for short-term transactions (under one year). Effective EE is equal to nondecreasing EE. Effective EPE is the average of the effective EE.

**Figure 4: Effective EE and Effective EPE**



## Comparing Credit Exposure to VaR Methods

### LO 29.2: Compare the characterization of credit exposure to VaR methods and describe additional considerations used in the determination of credit exposure.

**Value at risk** (VaR) is a measure used to estimate the risk of loss on a portfolio of financial/investment assets (e.g., stocks, bonds, derivatives, etc.). For example, if an asset portfolio has a one-day 10% VaR of $100,000, there is a 10% probability that the market value of the portfolio will fall by more than $100,000 over a period of one day. The characterization of credit exposure is similar to the characterization of VaR, although additional considerations are relevant to credit exposure, described as follows:

- *Application*: Credit exposure is defined for both pricing and risk management, whereas VaR is just for risk management. As a result, quantifying credit exposure is more difficult and may result in different calculations for both pricing and risk management purposes.
- *Time horizon*: VaR models are based on a relatively short time horizon, whereas credit exposure must be defined over many time horizons. The trend (i.e., drift) of market variables, their underlying volatility, and their levels of co-dependence become relevant for credit exposure, whereas for VaR, these elements are irrelevant due to the short time horizon. Also, while VaR tends to ignore future contractual payments and changes such as exercise decisions, cash flows, and cancellations, credit exposure must take these elements into account because they tend to create path dependency (i.e., credit exposure in the future depends on an event occurring in the past).
- *Risk mitigants*: Netting and collateral are examples of risk mitigants, designed to reduce the level of credit exposure. In order to estimate future levels of credit exposure, these mitigants need to be taken into account. Netting requires that the proper rules be applied, which may add a level of complexity. Future collateral adds a significant element of subjectivity, as the type of collateral and time to receive collateral must all be modeled even though they may be unknown.

## Credit Exposure Factors

### LO 29.3: Identify factors that affect the calculation of the credit exposure profile and summarize the impact of collateral on exposure.

The credit exposure profile is impacted by several factors, including:

- *Future uncertainty*: In situations where there is a single payout at the end of the life of a contract, uncertainty regarding the value of the final exchange increases over time. Foreign exchange forwards and FRAs often have single payouts at the end of their contract lives.
- *Periodic cash flows*: Unlike the situation where there is a single payout, when cash flows occur regularly, the negative impact of the future uncertainty factor is reduced. However, additional risk exists when periodic cash flows are not equal in each period and are based on variables that may change as is often the case in an interest rate swap with variable interest rates.

- *Combination of profiles*: This exists when the credit exposure of a product results from the combination of multiple underlying risk factors. A cross-currency swap (which combines a foreign exchange forward trade with an interest rate swap) is a good example of this factor.
- *Optionality*: Exercise decisions (e.g., a swap-settled interest rate swaption) will have an impact on credit exposure.

Collateral will also have a significant impact on credit exposure, as it typically reduces the level of credit exposure. However, determining the true level of risk reduction must take into account key parameters (e.g., minimum transfer amounts, thresholds, etc.); the margin period of risk; and other risks associated with collateral such as liquidity, operational risk, and legal risk.

In addition, the reality is that risk is not removed entirely even with collateral due to factors such as delays in receiving collateral, variations in collateral value (i.e., when the collateral is something other than cash), the granularity effect (i.e., key parameters prevent asking for all of the collateral actually required), and the path dependency of collateral (i.e., the amount called for depends on the amount collected in the past).

## Security Exposure Profiles

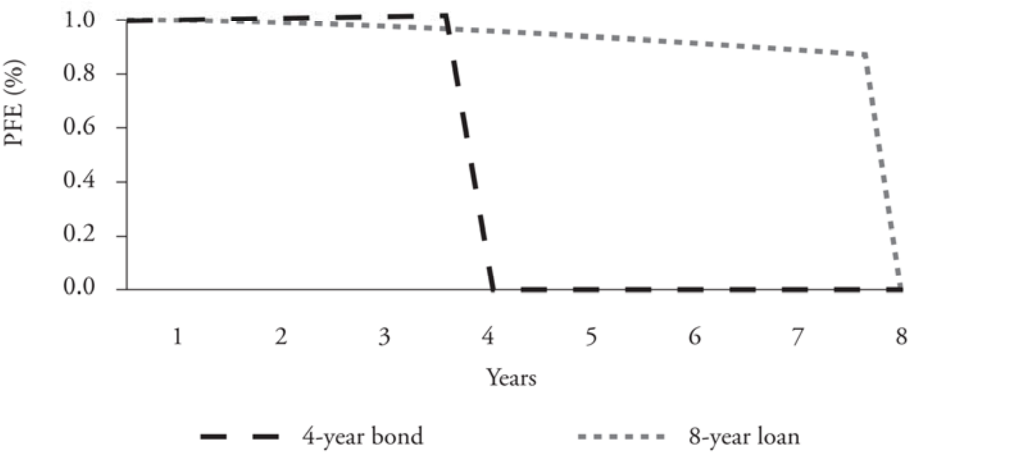
**LO 29.4: Identify typical credit exposure profiles for various derivative contracts and combination profiles.**

**Potential future exposure** (PFE) is defined as the maximum expected credit risk exposure for a specified period of time at a prespecified level of confidence. PFE is a measure of counterparty and credit risk exposures. Thus, the maximum credit risk exposure indicated by a PFE analysis is the upper bound on a confidence interval for future credit risk exposure. The ability to quantify counterparty credit exposure is impacted by time to maturity. There is more uncertainty related to market variables further into the future.

Examples of PFE are used to illustrate the credit exposure profile of various security types that result from different sources (e.g., maturity, option exercise, payment frequencies, default risk, and roll-off risk). In this section, a 99% confidence level is used to create the PFEs.

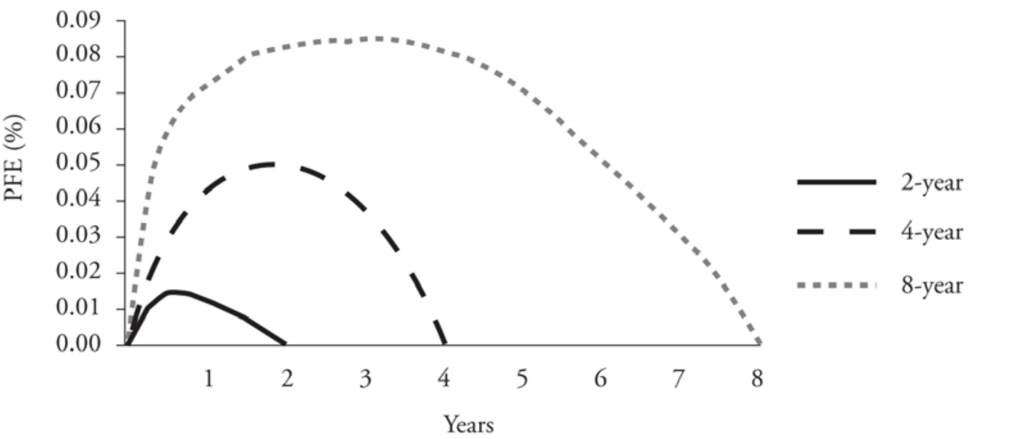
The PFE of bonds, loans, and repos are approximately equal to the notional value. The additional exposure of a four-year bond, as shown in Figure 5, is the result of interest rate risk. Bonds typically pay a fixed interest rate. If interest rates decline, then the exposure may increase. Figure 5 also illustrates the exposure for an eight-year loan. Loans typically have variable interest rates, and the exposure over time may decrease as a result of prepayments.

**Figure 5: Loan and Bond PFE**




Exposure profiles of swaps are typically characterized by a peak shape, as illustrated in Figure 6. This peaked shape results from the balancing of future uncertainties over payments and the roll-off risk of swap payments over time.

**Figure 6: Interest Rate Swap PFE**




The high volatility of FX rates, long maturities, and large final payments of notional value result in monotonically increasing exposures for foreign exchange products. Figure 7 illustrates that there is some exposure associated with interest rate risk (IR); however, the majority of the exposure results from the uncertainty regarding the final notional value payment associated with FX rate risk.

**Figure 7: Three-Year Cross-Currency Swap PFE (Exposure Impact of Interest and FX Rates)**

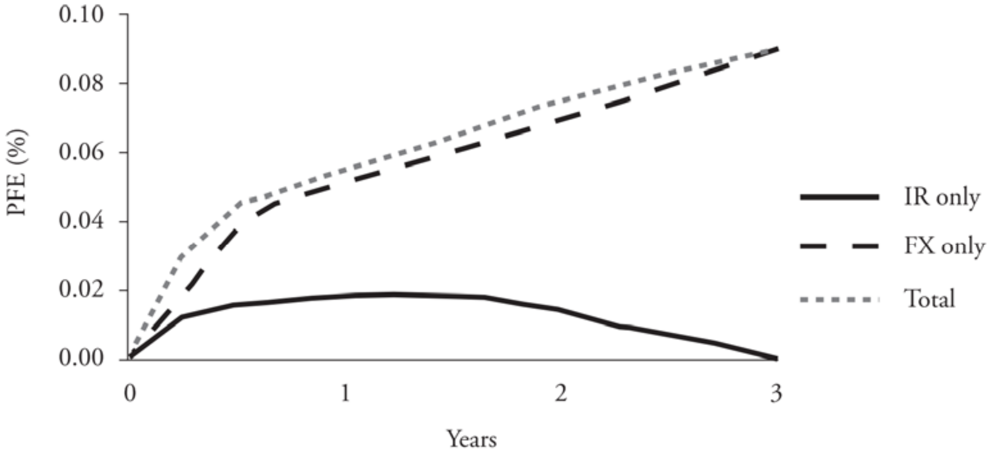
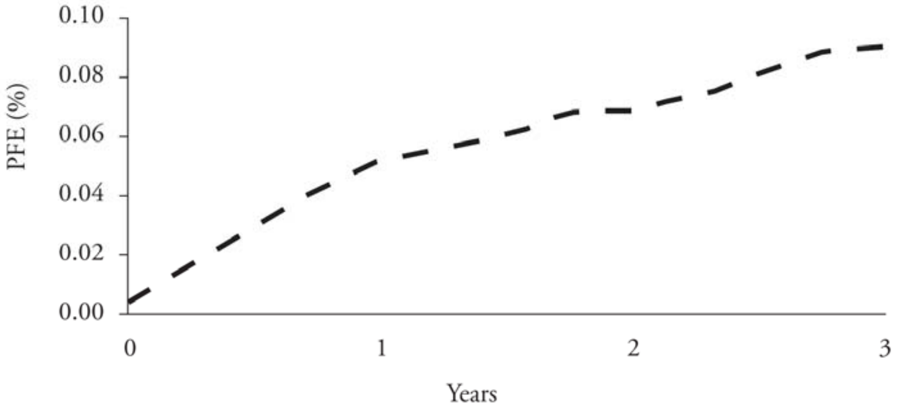


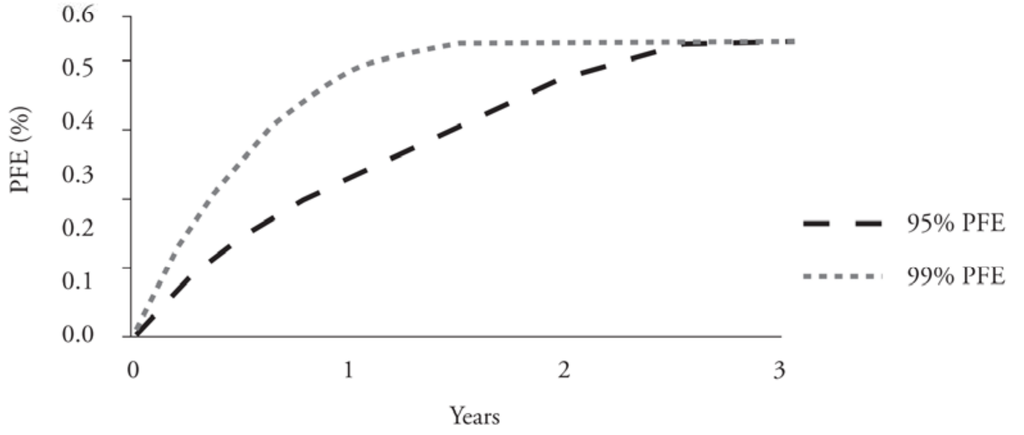

Figure 8 provides an exposure profile for a long option position (with up-front premium) and illustrates the increase over time of the exposure until the option is exercised. The exact shape of the graph can change when the option is near, in, or out of the money. However, the increase over time is similar for all options due to the fact that the option can be deep in the money.

**Figure 8: Option PFE**




The effect of **wrong-way risk** leads to considerable counterparty risk for credit derivatives. Figure 9 illustrates the exposures for a long-protection credit default swap (CDS) at the 95% and 99% confidence levels. The increase in exposures in early years is the result of the CDS premium (or credit spread) widening. The maximum exposure for the CDS occurs at a credit event where the notional value is paid less the recovery value. The 55% final exposure in this example is the result of a 45% recovery rate.

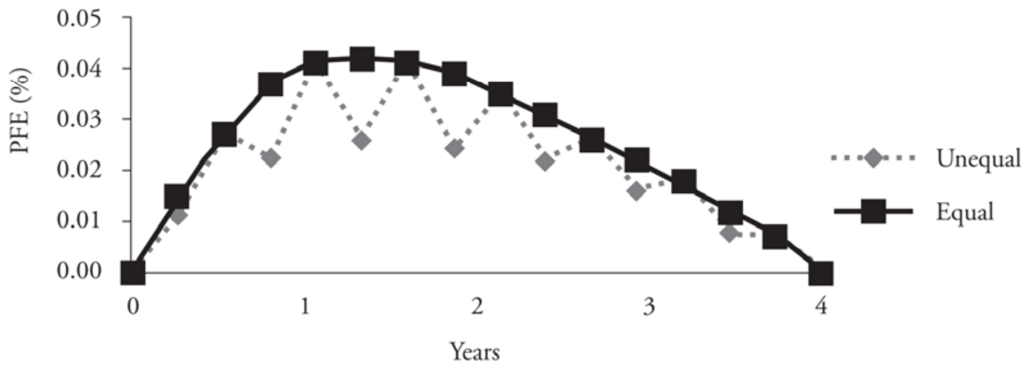
**Figure 9: Credit Derivative PFE**




## LO 29.5: Explain how payment frequencies and exercise dates affect the exposure profile of various securities.

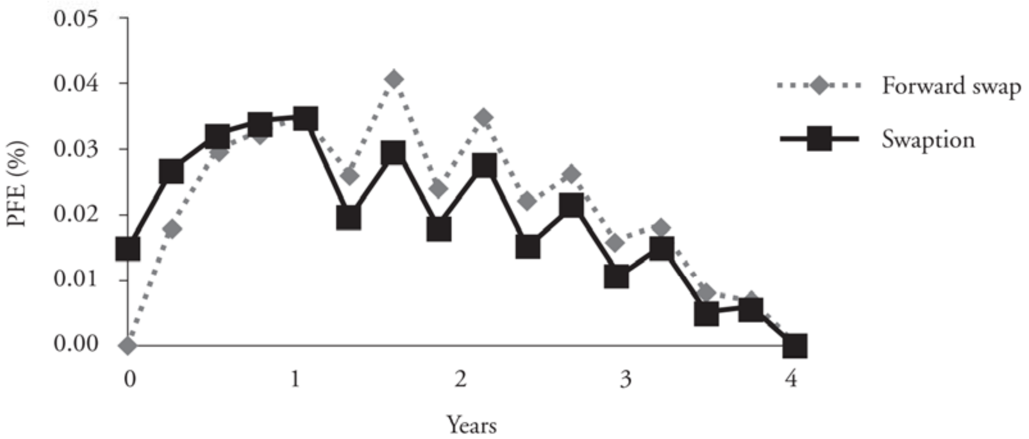
To illustrate the impact of payment frequencies, we can compare interest rate swap PFEs, assuming semiannual fixed payments are made and floating quarterly payments are received. Figure 10 illustrates that with unequal payments there is reduced exposure when payments are received more frequently than payments are made. Conversely, if a PFE were created for an interest rate swap where interest payments made were more frequent than interest payments received, it would have the reverse effect. In that case, the unequal payment PFE would show greater exposure than the equal payment PFE.

**Figure 10: PFE for Swap With Equal and Unequal Interest Payments**




Exercise dates result in more complex exposure profiles as illustrated in Figure 11, which shows an exposure profile for an interest rate swaption and forward swap with an exercise date of one year. The swaption in this example is swap-settled (as opposed to cash-settled) on the expiration date. The payment frequencies also differ for the swaps in this example. When compared to a forward swap, notice that the exposure is greater for the swaption prior to the one-year exercise date. This relationship reverses after the exercise point and the exposure for the forward swap is greater than the exposure for the swaption. This greater exposure is due to the fact that in some scenarios the forward swap has a positive value and the swaption is not exercised.

**Figure 11: PFE for Interest Rate Swaption and Forward Swap**




## Modeling Netting Agreements

**LO 29.6: Explain the impact of netting on exposure, the benefit of correlation, and calculate the netting factor.**

**Netting** agreements allow two parties to net a set of positions should one of the parties default. This type of risk is effectively modeled in Monte Carlo simulations. The benefits of netting are realized when MtM values have opposite signs for two trades. Thus, the netting calculation is done at the individual level prior to calculating the total expected exposure (EE). A single time horizon netting factor is defined by EE, and a weighted average EE over time defines the expected positive exposure (EPE).

It is also important to consider the relationship between netting and correlation. Positive correlations have lower netting benefits than negative correlations, with perfect positive correlation providing the least netting benefit. High positive correlations likely result in trades that are of the same sign, resulting in a small or zero netting benefit.

**Figure 12: Netting With Positive Correlations**

| | *MtM* | | *Total Exposure* | | |
|---|---|---|---|---|---|
| | *Trade 1* | *Trade 2* | *No netting* | *Netting* | *Netting benefit* |
| Scenario 1 | 15 | 5 | 20 | 20 | 0 |
| Scenario 2 | 5 | –5 | 5 | 0 | 5 |
| Scenario 3 | –5 | –15 | 0 | 0 | 0 |
| EE | | | 8.3 | 6.7 | 1.7 |

*Professor's Note: EE, or expected exposure, is the average of the netting figures assuming equal weight.*

We can, therefore, easily see that negative correlations provide stronger netting benefits, with perfect negative correlation leading to the greatest netting benefit. In this case, trades are perfectly offsetting, and the netting benefit is 100% because there is zero overall risk.

**Figure 13: Netting With Negative Correlations**

| | *MtM* | | *Total Exposure* | | |
|---|---|---|---|---|---|
| | *Trade 1* | *Trade 2* | *No netting* | *Netting* | *Netting benefit* |
| Scenario 1 | 15 | –5 | 15 | 10 | 5 |
| Scenario 2 | 5 | 5 | 10 | 10 | 0 |
| Scenario 3 | –5 | 15 | 15 | 10 | 5 |
| EE | | | 13.3 | 10.0 | 3.3 |

Overall, we can derive the following netting formula for the **netting factor** for any set of jointly distributed random variables across different asset classes:

$$\text{netting factor} = \frac{\sqrt{n + n(n-1)\bar{\rho}}}{n}$$

where:
n = number of exposures
$\bar{\rho}$ = average correlation

The netting factor will, therefore, be 100% when there is no netting benefit (correlation is 1) and 0% if the netting benefit is maximized. We also see that the netting benefit improves (i.e., netting factor declines) with a larger number of exposures and a lower correlation. If correlation is zero, the formula simplifies to $1 / \sqrt{n}$, implying that the netting factor for two independent exposures will be reduced to 71%, and for four exposures the netting factor declines to 50%.

Finally, it is important to note that the netting benefit also depends on the initial MtM of transactions. For example, a trade with strong overall negative MtM under all scenarios will have a strong netting benefit by offsetting some or all of the positive MtM of other trades. Similarly, a trade with strong overall positive exposure under all scenarios will reduce the netting benefit by offsetting some or all of the negative MtM of other trades.

## Impact of Collateral on Credit Exposure

### LO 29.7: Explain the impact of collateralization on exposure, and assess the risk associated with the remargining period.

When Party A has a positive exposure (e.g., receives cash flows in a swap transaction from Party B), Party A is said to have credit exposure because Party B could default. When exposure (i.e., mark-to-market value) is negative, Party B must post collateral to Party A to minimize the credit risk exposure.

When calculating an exposure profile, a risk manager should understand the factors that affect the collateral's ability to reduce risk. Specifically, factors that affect the calculation of

exposure include thresholds, minimum transfer amounts, rounding, independent amount, and the remargin period. These factors will be discussed throughout this section.

The **remargin period**, also known as the margin call frequency, is the period from which a collateral call takes place to when collateral is actually delivered. It is a period of extreme exposure to the counterparty seeking collateral. A prudent risk analyst will assume default of the counterparty that must post collateral during the remargin period. Steps that enter into the calculation of the number of days in the remargin period are as follows:

*Step 1:* *Valuation/margin call*: How long it takes to calculate current exposure to the counterparty and the market value of the collateral. These calculations help to determine if a valid call may be made.

*Step 2:* *Receiving collateral*: The period between when the counterparty receives the request and when it releases the collateral.

*Step 3:* *Settlement*: The time it takes to sell the collateral for cash. The type of security being settled determines the time necessary. Cash may be posted on an intraday basis, whereas government and corporate bonds may need one- and three-day settlement periods, respectively.

*Step 4:* *Grace period*: The amount of time afforded to the counterparty obligated to deliver the collateral in the event that the collateral is not received by the requesting counterparty after the call. This may be a short window of time before the delivering counterparty would be considered in default for a failure-to-pay credit event.

*Step 5:* *Liquidation/close-out and re-hedge*: The time needed to liquidate the collateral, close out, and re-hedge positions.

An example of a remargin period time line is found in Figure 14, along with the minimum period lengths that must be assumed according to Basel II. Over-the-counter (OTC) derivatives and repurchase agreements (repos) are separated as they are governed by different documentation. The length of a remargin period is a function of the collateral agreement, the counterparty in question, legal considerations, and the management structure of the institution in question. Also, the counterparty requesting the collateral could show leniency toward certain counterparties in the interest of maintaining harmonious business relationships.

**Figure 14: Remargin Period Time Line**

| | *OTC Derivatives* | *Repos* |
|---|---|---|
| Valuation/margin call | 2 days | – |
| Receiving collateral | 1 day | 1 day |
| Settlement | 2 days | 1 day |
| Grace period | 3 days | – |
| Liquidation/close-out and re-hedge | 2 days | 1 day |
| Total | 10 days | 3 days |
| Basel II minimum period | 10 days | 5 days |

## Measuring Exposure During the Remargin Period

Both expected exposure and potential future exposure measure the volatility of exposure over a given period of time. **Expected exposure** (EE) is the expected value of an exposure at a given point in time. During the remargin period, it is calculated as:

$$EE = \frac{1}{\sqrt{2\pi}} \times \sigma_E \times \sqrt{T_M} \approx 0.4 \times \sigma_E \times \sqrt{T_M}$$

where:
$\sigma_E$ = volatility of collateralized exposure
$\sqrt{T_M}$ = the remargin frequency (in years)

**Potential future exposure** (PFE) is what the value of the marked-to-market exposure might be at some future point in time. During the remargin period, it is calculated as:

$$PFE = k \times \sigma_E \times \sqrt{T_M}$$

where:
k = a constant that is a function of the confidence level (e.g., k = 2.33 for a 99% confidence level)

**Example: Computing PFE**

**Calculate** the worst-case change in the value of an exposure with 7% annual volatility perfectly collateralized by cash over a 10-day remargin period. Assume 250 trading days in the year and a 99% PFE confidence level.

**Answer:**

$$PFE = -2.33 \times 7\% \times \sqrt{10/250} = -3.3\%$$

Potential disadvantages of PFE calculations include:

- It assumes a strongly collateralized position. PFE fails to work under a large threshold or minimum transfer amount, which produces a partially uncollateralized exposure.
- The analysis fails to account for the uncertainty of collateral volatility.
- Liquidity and liquidation risks are not considered.
- Volatility may differ from expected or implied volatility at the time of the collateral call and may not assume counterparty default.
- Wrong-way risk is not taken into account.

**Collateral volatility** must be calculated when a decline in the value of noncash collateral has the potential to create undercollateralization. The PFE formula is used for this calculation.

When there is no correlation between the volatility of the underlying exposure and that of the collateral, overall volatility is calculated as follows:

$$\sqrt{\text{variance of noncash collateral} + \text{variance of underlying exposure}}$$

For example, if the volatility of the noncash collateral was 8% and the volatility of the underlying exposure was 5%, the overall volatility would be computed as:

$$\sqrt{8\%^2 + 5\%^2} = 9.4\%$$

This volatility measure would be used in the PFE formula to reflect the additive exposure of the collateral and volatility of the underlying exposure. In this example, collateral lessens exposure but increases the volatility of the position due to the volatility inherent in the collateral itself.

There are also situations where there is a negative or positive correlation, $\rho$, between the trade and the collateral. For example, assume a 10-year swap is collateralized with a 15-year government bond that is interest rate–sensitive. The volatilities are 4% for the swap and 6% for the bond. The effective volatility of this position is calculated as follows:

$$\text{effective volatility} = \sqrt{4\%^2 + 6\%^2 - 2 \times 4\% \times 6\% \times \rho}$$

The overall risk of the position as a function of correlation is then calculated as:

$$k \times \text{effective volatility} \times \sqrt{T_M}$$

## Risk-Neutral vs. Real Probability Measures

**LO 29.8: Explain the difference between risk-neutral and real-world parameters, and describe their use in assessing risk.**

A risk-neutral parameter is often assumed in arbitrage pricing models where hedging is used. Conversely, when exposures are calculated for risk management purposes, the parameters are not risk-neutral but are based on real historical data and common sense. Parameters used for drifts and volatilities are market-driven (i.e., risk-neutral) and may not always reflect historical data or expected events.

The length of data to use for parameter estimation has important implications. A shorter data sample window results in poor statistics, while a longer data sample window gives more weight to older, less relevant data. For example, when the volatility of a market suddenly and dramatically increases, a model using a longer data sample window for parameter estimation will only gradually reflect this increase as the data sample window moves forward in time.

An implied volatility will reflect the market uncertainty immediately. However, caution should be used when applying implied volatility parameters in exposure models. This is

illustrated in the following example scenario as counterparty risk, interest rate drift, and longer time periods will have important impacts.

Consider the PFE for two cross-currency swaps with the same maturity, where one of the swaps pays a higher interest rate and the other swap receives the higher interest rate payment. The swap paying the higher interest rate has a greater exposure than the reverse swap due to the fact that it has a significantly higher gain on the notional value at the maturity of the swaps. In addition, over the long term, the interest rate drift dominates the implied volatility measure. This causes the PFE for the swap receiving the higher interest rate to remain relatively flat.

## Key Concepts

### LO 29.1

Important metrics for credit exposure include the following: expected MtM, expected exposure (EE), negative expected exposure (NEE), potential future exposure (PFE), expected positive exposure (EPE), expected negative exposure (ENE), effective EE, effective EPE, and maximum PFE.

### LO 29.2

Although value at risk (VaR) and credit exposure are similarly used to estimate the risk of loss, additional considerations related to credit exposure that must be accounted for include how it is applied (exposure is defined for pricing and risk management), the time horizon (exposure has a much longer time horizon than VaR), and risk mitigants (netting and collateral).

### LO 29.3

The credit exposure profile is impacted by factors such as future uncertainty, periodic cash flows, profile combinations, and optionality. Collateral will also impact exposure, typically in a favorable way. However, risk reduction may be limited by the existence of key parameters (thresholds, minimum transfer amounts), characteristics of collateral (delays, value variations, granularity, path dependency), and other risks (liquidity, operational, legal) associated with collateral.

### LO 29.4

The PFE of bonds, loans, and repos are approximately equal to the notional value or 100%. PFEs of swaps have a peaked shape. PFEs of long option positions or FX products monotonically increase. The maximum PFE for credit default swaps occurs at a credit event where the notional value less the recovery value is paid.

### LO 29.5

With unequal payments, there is reduced exposure that results when payments are received more frequently than payments are made. Exercise dates result in more complex exposure profiles.

### LO 29.6

Positive correlations between contract mark-to-market values have lower netting benefits than negative correlations, with perfect positive correlation providing the least netting benefit and perfect negative correlation the most benefit.

## LO 29.7

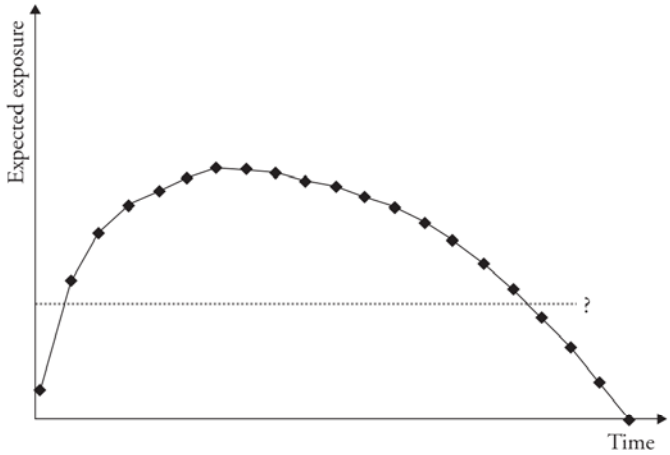
The remargin period is the period from which a collateral call takes place to when collateral is actually delivered.

## LO 29.8

Exposure management should focus on market-implied (risk-neutral) parameters when appropriate.

# Concept Checkers

1. Which metric for credit exposure is represented by the "?" in the following graph?




A. Expected positive exposure (EPE).
B. Potential future exposure (PFE).
C. Effective EE.
D. Effective EPE.

2. Miven Corp. has two trades outstanding with one of its counterparties. Which of the following scenarios would result in the greatest netting advantage for Miven?
A. The two trades have strong positive correlation.
B. The two trades have weak positive correlation.
C. The two trades are uncorrelated with each other.
D. The two trades have strong negative correlation.

3. Which of the following security types will most likely result in a peaked shape for the exposure profile represented by potential future exposure (PFE)?
A. Long option position.
B. Foreign exchange product.
C. 10-year loan with a floating rate payment.
D. Swap.

4. Which of the following statements best describes the benefit of netting risk exposures? The benefits of netting are realized when:
A. marked-to-market (MtM) values have high structural correlations for two trades.
B. marked-to-market (MtM) values have opposite signs for two trades.
C. expected exposure (EE) values are minimal.
D. expected future exposure (EFE) values have zero correlation.

5. Time steps that enter into the calculation of the number of days in the remargin period include all of the following except:
   A. valuation/margin call.
   B. posting collateral.
   C. settlement.
   D. close-out and re-hedge.

## Concept Checker Answers

1. **A** Expected positive exposure (EPE) is equal to average EE over time. It is a useful single amount to quantify exposure.

2. **D** The greatest netting benefit among the scenarios presented occurs when the two trades have a strong negative correlation. In this case, a large portion of the negative exposures will offset positive exposures.

3. **D** Exposure profiles of swaps are typically characterized by the peaked shape that results from balancing future uncertainties over payments and roll-off risk of swap payments over time.

4. **B** The benefits of netting are realized when MtM values have opposite signs for two trades.

5. **B** The time period from which the request for collateral is received to which it is released refers to the receipt of collateral, but it does not involve its actual posting. All of the remaining items are part of the remargin process.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Default Probability, Credit Spreads, and Credit Derivatives

Topic 30

## Exam Focus

This topic discusses the theory of default probability and its practical application to credit spreads and credit derivatives. For the exam, be able to explain the difference between cumulative and marginal default probabilities. Also, be able to calculate risk-neutral and real-world default probabilities in pricing derivative contracts. Finally, understand how recovery rates are estimated, and the underlying mechanics of credit default swaps (CDS) and portfolio credit derivatives.

## Default Probability

### LO 30.1: Distinguish between cumulative and marginal default probabilities.

The **cumulative default probability**, *F(t)*, represents the likelihood of counterparty default between the current time period and a future date, *t*. Intuitively, the cumulative probability of default must be an increasing function. Further, the probability of default at the current point in time can be interpreted as zero and increases over time, reaching a maximum of 100%, which implies that all counterparties will eventually default. That is, given a sufficiently long period of time, some unforeseen event or extreme economic circumstance will cause even the most creditworthy companies to become insolvent.

The **marginal default probability** denotes the likelihood of counterparty default between two future points in time denoted $t_1$ and $t_2$. Marginal default probabilities must be non-negative to make economic sense. In equation form, marginal default probability can be expressed as follows:

$$q(t_1, t_2) = F(t_2) - F(t_1)$$

where:
$t_1 \leq t_2$

## Risk-Neutral vs. Real-World Default Probabilities

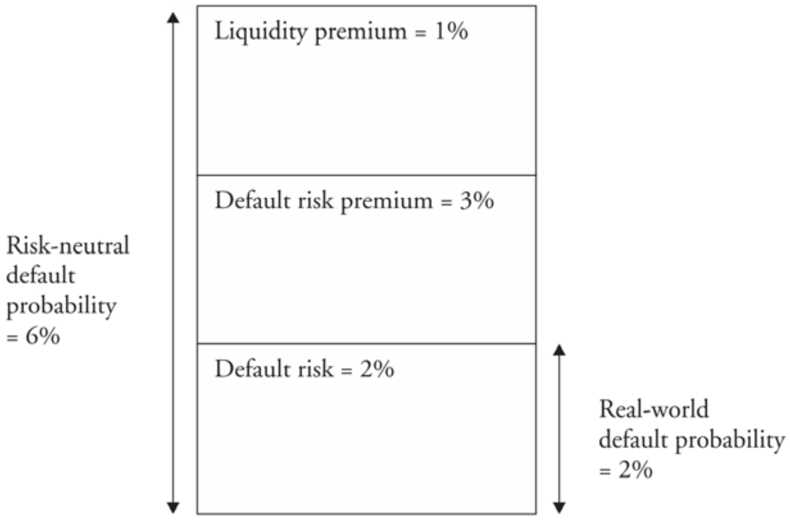
**LO 30.2: Calculate risk-neutral default probabilities, and compare the use of risk-neutral and real-world default probabilities in pricing derivative contracts.**

**Risk-neutral default probabilities** are calculated from market information, while **real-world default probabilities** are based on historical data. Typically, real-world default probabilities are less than risk-neutral default probabilities. Although the difference between risk-neutral and real-world default probabilities may seem to be just semantics, the difference is extremely important.

Risk-neutral default probabilities represent the estimated parameter value determined from an observable market price. If the pricing model is assumed correct, the unknown parameter can be determined by solving for the parameter value that makes the model price equal to the market price. A good example is the implied volatility from an observed option price using the Black-Scholes-Merton model. The risk-neutral probability of default is the estimated parameter value that forces the observed pricing model to equal the market price. However, there may be other factors in addition to real-world default probability, such as a liquidity or default risk premium that are aggregated into the risk-neutral default probability calculation. Hence, the risk-neutral default probability is likely to overstate the actual probability of default.

A simple numerical example can further illustrate this point. Suppose there is a one-period, zero-coupon bond that will mature with face value of \$100. The obligation will default with 2% probability. For simplicity, assume no recovery in the event of default. This scenario is illustrated in Figure 1. Ignoring the time value of money, the expected value of the cash flows would be (\$100 × 0.98) + (\$0 × 0.02) = \$98. However, a rational investor would never pay \$98 because there is chance of zero recovery due to default. Hence, the investor will price the bond lower at, for example, \$95 to compensate for the uncertainty of the return. This \$3 reduction represents the **default risk premium**. Further, suppose the investor feels that market conditions may impact the ability to sell the bond in a timely fashion and imposes an additional \$1 reduction (i.e., **liquidity premium**) for such liquidity concerns. The final price is then \$94. Because \$94 is the observed market price, the risk-neutral probability of default is computed as 6%, which is in sharp contrast to the actual real-world probability of default of 2%.

**Figure 1: Default Probabilities**




The risk-neutral probability can be displayed in equation form as follows:

risk-neutral default probability = liquidity premium + default risk premium + real-world default probability

It is important to note the appropriate use of each calculation. The real-world default probability (i.e., actual probability of default by a counterparty) should be incorporated into quantitative risk and return assessment conducted during the risk management process. Risk-neutral default probabilities should be incorporated into hedging decisions because they are derived from actual market prices.

## Estimation Approaches

**LO 30.3: Compare the various approaches for estimating price: historical data approach, equity based approach, and risk neutral approach.**

### Historical Data Approach

The most direct assessment of default probabilities is to use historical default data to forecast future default probabilities. In this case, a transition matrix is helpful in calculating default probabilities because it identifies the historical probabilities of credit rating migration between periods. Cumulative default probabilities can be estimated by matrix multiplication of the transition matrix with itself. This methodology assumes the transition matrix is constant over time and hence unaffected by the business cycle, an observation not supported by empirical evidence. In general, credits are more likely to be downgraded than upgraded. In addition, the cumulative probability of default for investment-grade credits increases more rapidly than for noninvestment grade credits over a given period. This is simply a case of mean-reversion.

## Equity-Based Approaches

Equity-based approaches for estimating real-world default probabilities include the Merton model, the KMV approach, and CreditGrades™. Equity-based approaches allow for a dynamic estimation of default probability as opposed to the static estimate provided by the historical approach.

The **Merton model** uses equity market data to estimate default probabilities. In this model, the equity value is viewed as a call option with a strike price equal to the firm's debt level. This model assumes the firm has a single-period, zero-coupon bond outstanding and hence can only default at maturity. Therefore, the estimation of default probabilities is reduced to assessing where the firm's asset value will fall below its outstanding debt level.

The **KMV approach** uses a proprietary approach built on the Merton model, but it relaxes several of its assumptions. The steps to the KMV approach are as follows: (1) volatility and market value estimates are calculated, (2) the **distance to default** (the number of standard deviations between current asset values and the debt repayment amounts) is calculated, and (3) historical default data and distance to default are used to estimate the expected default probability.

**CreditGrades™** uses observable market data and balance sheet information to create a model that is simpler (due to fewer model parameters) and easier to replicate than other equity-based approaches. Importantly, empirical data is not utilized in this model.

## Risk-Neutral Approach

The risk-neutral probability of default is derived from the observed credit spread and the market price of a traded credit security. In practice, this is challenging because there is no single credit spread but several possible estimates, including credit default swap (CDS) premiums, bond prices relative to a benchmark Treasury curve, and spreads on asset swaps.

To model this process, consider a credit with a constant 9% probability of default per year. Hence, the default probability in the first year is 9%, 8.2% in year 2 [= probability of no default in prior year × probability of default in current year = (100% – 9%) × 9% = 91% × 9%], 7.5% in year 3 (= 91% × 91% × 9%), and so on. It follows that the cumulative default probabilities for these periods are 9%, 17.2%, and 24.6%, respectively, and that the conditional default probability (i.e., the default probability in a period assuming no default in prior periods) is 9%.

Using the Poisson process, the default probability for future time period *u* is expressed as follows:

$$F(u) = 1 - \exp(-h \times u)$$

where *h* is the hazard rate of default (i.e., the default probability for an infinitesimally small time period).

*Professor's Note: The notation* exp(x) *is equivalent to* $e^x$. *Therefore, use the exponential function on your calculator for these calculations.*

For example, assume h = 4.7% and u = 2. In this case, default probability can be solved as follows:

9% = 1 – exp(–0.047 × 2)

This result matches the previous discrete example very closely. Utilizing the observation that h ≈ spread / (1– recovery) yields the approximate formula for risk-neutral probability:

$$F(u) = 1 - \exp\left[-\frac{\text{spread}}{1 - \text{recovery}} \times u\right]$$

While this derivation is simple and elegant, a significant problem remains, namely, two parameters (recovery rate and probability of default) must be estimated based on only one observation of the credit spread. Standard procedure is to assume a fixed recovery rate, typically around 40%, to derive market-based default probabilities.

Finally, the marginal probability of default can be approximated as:

$$q\left(t_{i-1,}\ t_i\right) \approx \exp\left[-\frac{\text{spread}_{t_{i-1}}}{1 - \text{recovery}} \times t_{i-1}\right] - \exp\left[-\frac{\text{spread}_{t_i}}{1 - \text{recovery}} \times t_i\right]$$

Empirical evidence indicates that risk-neutral default probabilities are significantly larger than real-world default probabilities. Perhaps counterintuitively, the difference is larger for higher-quality credits and has meaningful impacts on hedging. For practical purposes, real-world default probabilities are more appropriate if counterparty risk is ignored (or considered negligible). Conversely, if one wants to hedge against counterparty risk, then risk-neutral probabilities must be considered.

## Recovery Rates

### LO 30.4: Describe how recovery rates may be estimated.

**Recovery rates** refer to the percentage of par (i.e., notional) value that is realized (i.e., recovered) after default. Generally, ex-ante recovery rates are not directly observable because credit products are priced jointly, factoring in default probabilities and recovery rates. Hence, the calculation of one depends on an estimate of the other.

In a perfect world, recovery rates would be derived from observed market prices of **recovery swaps** where the counterparties agree to pay/receive the difference between ex-post actual recovery and ex-ante agreed-upon fixed recovery rate. The problem is that these swaps are not typically traded.

As an alternative, historical recovery rates from defaulted securities can be utilized. This simple approach is complicated by several factors. First, recovery rates vary by industry and time periods. That is, there is strong evidence of clustering of defaults during economic downturns and, within a given industry, generally lower recovery rates. Second, higher default rates have a negative relation with recovery. In other words, recovery amounts tend to be lower during periods of above-average defaults. Third, recovery rates are clearly related to the capital structure whereby more senior claims will have higher recovery rates than subordinated or junior claims. Fourth, the potentially long, drawn-out process in bankruptcy proceedings can lead creditors to selling claims prematurely in the market. Hence, the realized (settled) recovery may be different than the eventual (actual) recovery.

## Credit Default Swaps

**LO 30.5: Describe credit default swaps (CDS) and their general underlying mechanics.**

The most well-known credit derivative is the **credit default swap** (CDS). The CDS is an insurance-like security that transfers credit risk from the protection buyer to the protection seller for a pre-specified premium. The contract must specify the reference entity (e.g., corporate credit, sovereign borrower), reference obligation, settlement procedures, and the notional amount of protection. Note that the reference entity is not a counterparty in the CDS. In addition, the CDS must specify the universe of credit events (e.g., bankruptcy, insolvency, restructuring) for the reference entity that will trigger a payment from the party long the credit risk to the party short the credit risk at the initiation of the agreement.

The dramatic rise in popularity of CDS contracts throughout the 2000s led to some standardization of CDS contracts. Typically, high-quality issuers will trade with fixed coupons of 100 bps per annum while high-yield issuers will trade with coupons of 500 bps per annum. An additional up-front, one-time payment may be made from the buyer of protection to the seller of protection (or vice versa) if the actual premium is higher or lower than the fixed coupon.

In case of default, CDS may settle in physical terms or in cash terms. For physical settlement, the required number of bonds with par value equal to the notional is delivered to the counterparty in exchange for a cash payment also equal to the notional principal. This method requires the protection buyer to physically deliver the bonds. Hence, if the buyer does not actually own the bonds, the buyer will have to purchase them in the open market. This creates an additional risk that the sudden demand for the defaulted securities will raise the price as many protection buyers will need to purchase the bond. This event is known as a **delivery squeeze.** However, an advantage of physical delivery is that there is no need to determine the size of the loss because the full notional is transferred in default.

The cash settlement for default has some important differences relative to physical settlement. Because the bonds are not transferred from the protection buyer to the protection seller under cash settlement, there is no need to own or purchase the defaulted securities. Rather, the protection seller makes a single compensatory payment of par (i.e., the post-event market price). A problem arises because the market price is fluid based on the demand for the defaulted debt. To further standardize the process, an auction is held approximately 30 days after default, at which point the settlement price is determined.

## The Credit Spread Curve

### LO 30.6: Describe the credit spread curve and explain the motivation for curve mapping.

The **credit spread curve** is essentially a yield curve of credit spreads for different maturities. The first step to creating the curve is to plot the most liquid credit spreads observable in the market for a single credit or credit rating, generally from CDS premiums or bond spreads, for all available maturities. While this concept is appealing, implementation is challenging because of data limitations. Even if the aforementioned securities (across several maturities) have sufficient liquidity, there are still many gaps in the curve that require a subjective estimation procedure to generate a smooth curve.

Plotting the curve is further complicated by the choice of reference. For example, construction of a AA-rated credit curve would have a relatively large choice of securities to infer credit spreads. Conversely, a more narrowly defined credit curve based on a particular industry sector or geography would limit the available data points, introducing more subjectivity into the curve.

An alternative method uses the credit spread around a single, liquid observation (e.g., credit spread with five years to maturity) to map the entire curve. For illustration, suppose the relevant five-year bond yield is 6%, and the maturity-matched benchmark is yielding 5%. This observation is considered to be one data point on the "mapped" credit curve. The remaining points on the credit curve are "mapped" by adjusting the index upward for all other maturities. In our example, the entire mapped curve would be estimated to be 120% of the index curve. A secondary question raised is the identification of an appropriate index.

## Portfolios of Credit Derivatives

### LO 30.7: Describe types of portfolio credit derivatives.

Credit derivatives can be combined into portfolios to form new products. The most popular of these products is the CDS index, which is typically structured as an equally weighted index of the underlying credit default swaps. Interestingly, the CDS index will not price exactly as an equally weighted basket of the underlying credits due to institutional factors such as variation in the bid-offer, credit event triggers, and up-front payments.

Index composition varies based on geography (e.g., North American, European, Asian markets) and other factors such as maturity. The two most popular (and liquid) indices are the CDX NA IG and iTraxx Europe. Both indices consist of 125 equally weighted, investment grade CDSs, with the primary difference being that the CDX NA IG uses North American entities and the iTraxx Europe uses European entities.

In contrast to traditional indices such as the S&P 500, CDS indices are created with a fixed maturity and static constituents. That is, if there is a significant credit event, the affected credit entity will be removed, but not replaced, from the index. The index will continue to trade based on the remaining non-defaulted credits, and the new notional principal of the index would be based on the remaining entities.

In addition, credit indices roll every six months. That is, a new on-the-run CDS index series is created every six months with new constituents based on credit events, rating changes, and CDS premium changes. However, previous index series continue to trade. Series maturities are typically five, seven, and ten years, with the five-year index being the most popular. The goal is to ensure that the newly created indices are homogenous with the overall credit quality of the previous portfolio and reflective of current market conditions. Lastly, the indices trade with a fixed coupon (e.g., 100 bps for investment grade indices and 500 bps for speculative grade indices), which simplifies the trading and marking-to-market of the indices.

## LO 30.8: Describe index tranches, super senior risk, and collateralized debt obligations (CDOs).

**Index tranches** create a capital structure for the credit index whereby the entire loss distribution is divided into mutually exclusive ranges. The losses are absorbed sequentially by the equity, mezzanine, senior, and super-senior tranches. Each tranche is described by its attachment point (X%) and detachment point (Y%), denoted [X%, Y%], and the width of each tranche is Y% – X%. It follows that the subordination level for each tranche is X%. That is, there is no loss experienced by the tranche until X% of losses has occurred in the index. Lower-level tranches receive higher returns and possess higher risk than higher level tranches. Lastly, the CDX NA IG and iTraxx Europe have predefined equity tranche levels of 0% – 3%, but they differ on the size of the mezzanine and senior tranches.

**Super-senior tranches** represent the portion of the capital structure for credit indices that has the highest subordination level and lowest probability of incurring losses. Informally, these tranches are termed *super triple-A* and *quadruple A tranches* to distinguish their lower relative risk from AAA-rated tranches. For practical purposes, the likelihood of sufficient defaults to reach the super-senior attachment point is highly unlikely. To gain some insight into this process, the required defaults to breach a tranche with a subordination level of X% can be expressed in general form by:

$$\text{number of defaults} = n\left(\frac{X\%}{1 - \text{recovery}}\right)$$

Note that both the subordination level and recovery rate assumptions are implicit in this calculation. As an illustration, suppose a super-senior tranche has an attachment point of 30% (which happens to be the subordination level for CDX), 100 underlying credits, and an assumed recovery rate of 40%. This tranche will require 50 defaults to cause economic loss to the super-senior tranche, shown as follows:

$$\text{number of defaults} = 100\left(\frac{30\%}{1 - 40\%}\right) = 50$$

In summary, the probability of impairments to the super-senior tranche is extremely small due to the high level of subordination. Hence, the credit risk of these tranches is not a major concern. The primary risk of these tranches is counterparty risk (termed *super-senior risk*) as this risk is positively correlated to tranche seniority. That is, higher seniority tranches have higher levels of counterparty risk. Unfortunately, it is nearly impossible for institutions to efficiently hedge this super-senior risk.

**Collateralized debt obligations** (CDOs) can be thought of as customized baskets of debt instruments segmented broadly into senior, mezzanine, and equity tranches. Because the underlying portfolio is not necessarily equally weighted, the specific tranche attachment and detachment points are not standardized, but similar to index tranches, the credit risk is concentrated in the equity tranche and the senior tranches are unlikely to suffer losses.

CDOs are typically divided into two broad categories: synthetic CDOs and structured finance securities. **Synthetic CDOs** are custom-made instruments for a specific transaction. From a trading perspective, each tranche may trade separate from the rest of the capital structure. **Structured finance securities**, including collateralized loan obligations (CLOs), mortgage-backed securities (MBSs), cash CDOs, and related instruments, typically involve more complex waterfall structures to determine payouts to different tranches. As a result, the individual tranches cannot be traded separately.

## Key Concepts

### LO 30.1

Cumulative default probability is the probability a counterparty will default before time *t*. The cumulative default probability function, *F(t)*, increases over time, eventually reaching 100%. The marginal default probability is the probability of default between two future dates: $q(t_1, t_2) = F(t_2) - F(t_1)$, where $t_1 \leq t_2$.

### LO 30.2

Risk-neutral probabilities represent estimates of default probability based on observed market prices of securities (e.g., bonds, credit default swaps). However, the market price aggregates actual real-world default probabilities with credit premiums, liquidity discounts, and possibly other factors. Hence, the risk-neutral probability overstates the actual real-world default probability. Risk-neutral probabilities are useful for hedging considerations, while real-world default probabilities are useful for quantitative risk assessment.

### LO 30.3

There are three approaches to estimate default probabilities: (1) the historical data approach, (2) equity-based models (Merton, KMV, and CreditGrades™), and (3) the risk-neutral approach. Historical data uses transition matrices based on historical credit migration and is limited by the static nature of the data. Equity models view firm equity as a call option with a strike price equal to debt level. Risk-neutral models use observed credit spreads to estimate hazard rates used in a Poisson process. An important limitation is that market-observed spreads jointly factor into default probability and recovery rate (i.e., an implicit recovery rate must be assumed).

### LO 30.4

Recovery rates represent the percentage of principal available to creditors after default. Recovery rates depend on overall market conditions, industry, and seniority in the capital structure. Historically, there is a strong negative correlation with default frequency and recovery rates.

### LO 30.5

Credit default swaps (CDSs) are liquid contracts that transfer credit risk from protection buyers to protection sellers. Predefined credit events include bankruptcy, insolvency, and restructuring to reduce post-event disputes. Settlement may be physical (i.e., deliver par value of notional principal in exchange for cash payment in the amount of notional principal) or in cash (cash transfer from seller to buyer of protection). Premium payments are fixed (e.g., 100 bps for strong credits and 500 bps for weak credits), plus a one-time, up-front payment to adjust for the specific credit quality of the reference entity.

### LO 30.6

The credit spread curve is a term structure plot of credit spreads against maturity. The lack of liquid securities may create large gaps in the curve. The mapped curve can be created via estimation techniques or by adjusting a chosen index upward to match the credit spread of a single, liquid observed credit.

### LO 30.7

Credit derivatives can be structured into portfolios to simplify trading and marking-to-market of broad credit movements. Indices are equally weighted, have fixed maturity, and trade with fixed coupons (e.g., 100 bps for high-quality issuers and 500 bps for high-yield issuers). In addition, standardized indices, such as the CDX NA IG and iTraxx Europe, potentially reconstitute their indices every six months.

### LO 30.8

Index tranches are standardized slices of the capital structure from a portfolio of CDSs. The tranches have predefined attachment and detachment points where equity, mezzanine, and senior tranches represent increasingly safe securities. Super-senior tranches represent the safest portion of the capital structure in a securitization. While the risk of default for super-senior tranches is low, counterparty risk is a concern. Collateralized debt obligations (CDOs) are pools of credits and can be separated into synthetic (custom-made tranches) CDOs or structured finance securities, including MBSs, CLOs, and similar instruments (rules-based cash flow distribution).

## Concept Checkers

1. Which of the following statements about cumulative and marginal default probabilities is most accurate?
   A. Both functions increase over time.
   B. Neither function increases over time.
   C. Only the cumulative default probabilities increase over time.
   D. Only the marginal probabilities increase over time.

2. Based on the following information, what are the the risk-neutral and real-world default probabilities?
   - Market price of bond is 92.
   - Liquidity premium is 1%.
   - Credit risk premium is 2%.
   - Risk-free rate is 2.5%.
   - Expected inflation is 1.5%.
   - Recovery rate is 0%.

| | Risk-neutral probability | Real-world probability |
|---|---|---|
| A. | 5% | 8% |
| B. | 8% | 5% |
| C. | 6% | 8% |
| D. | 5% | 6% |

3. Robin Hudson, FRM, was discussing the various methods to estimate default probabilities with her colleague Kate Alexander, FRM. Hudson made the following comments:
   I. Transition matrices are an important component of the risk-neutral approach.
   II. Hazard rates measure the instantaneous conditional default probability.
   III. Risk-neutral default probabilities are downward biased estimates of real-world default probabilities.

   How many of these statements should Alexander agree with?
   A. None of the statements.
   B. One statement.
   C. Two statements.
   D. Three statements.

4. Which of the following statements is most likely correct about recovery rates?
   A. Recovery rates vary inversely with capital structure seniority.
   B. Historical recovery rates are fairly constant across industries.
   C. Recovery rates are highest during economic downturns.
   D. Actual recovery rates may differ substantially from settled recovery rates.

5. Which of the following statements about credit default swaps is most accurate?
   A. CDSs transfer credit risk and market risk from the protection buyer to the protection seller.
   B. CDSs transfer credit risk from the protection buyer to the issuer of the underlying credit.
   C. Physical settlement requires knowledge of the post-default market price.
   D. Cash settlement avoids the problem of a delivery squeeze.

## Concept Checker Answers

1. **C** The cumulative default probability function begins at zero and eventually reaches 100% and must therefore increases over time. Marginal probabilities of default are always positive but are not necessarily increasing over time.

2. **B** The risk-neutral default probability is approximately 8% because the market price is 92% of par.

   risk-neutral probability = real-world probability + credit risk premium + liquidity premium

   8% = real-world probability + 2% + 1%

   real-world probability = 8% – 3% = 5%

3. **B** Only statement II is correct. Transition matrices are more likely to be used in the historical approach. Empirical evidence shows that real-world default probabilities are significantly lower than risk-neutral default probabilities.

4. **D** Settled recovery occurs fairly soon after the credit event (e.g., CDS auction or sale of defaulted bond), while actual recovery can occur years later based on the bankruptcy resolution. Recovery rates increase with capital structure seniority, are lowest during economic downturns, and vary significantly across industries.

5. **D** One advantage of the cash settlement procedure is that no securities are actually traded so the risk of delivery squeeze (i.e., rising price as protection buyers purchase reference entities in the open market) is negligible.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Credit Value Adjustment

Topic 31

## Exam Focus

The pricing of counterparty risk is a function of the credit exposure and default probability of a counterparty. For the exam, know how to calculate a credit value adjustment (CVA) in the presence of unilateral contracts. Also, understand the concepts of incremental and marginal CVA and know how to estimate CVA as a spread.

## Pricing Counterparty Risk

**LO 31.1: Explain the motivation for and the challenges of pricing counterparty risk.**

The pricing of counterparty risk (i.e., how much to charge a counterparty for the risk that it may default) is a function of the credit exposure and default probability of a counterparty. Accurate pricing of a counterparty's risk generates reserves to absorb potential losses due to that counterparty's default. Pricing counterparty risk needs to account for risk mitigants (e.g., netting, collateralization).

The price of counterparty risk approximates to the value of the risk of all outstanding positions with a counterparty and exists in addition to the price of the financial instrument itself that the counterparties use (e.g., a swap). Best practices will organize responsibilities as to who should calculate counterparty risk within the financial institution. The challenge in pricing this type of risk arises with bilateral derivatives contracts (e.g., swaps with fixed and floating components) rather than one-way payment instruments such as bonds.

## Credit Value Adjustment

**LO 31.2: Describe credit value adjustment (CVA).**

**LO 31.3: Calculate CVA and the CVA spread with no wrong-way risk, netting, or collateralization.**

The **credit value adjustment** (CVA) is defined as the expected value or price of counterparty credit risk. A positive value represents a cost to the counterparty that bears a greater propensity to default. A risky security transaction has a risk-free price with no counterparty risk and an adjustment for counterparty risk (i.e., risky value = risk-free value – CVA).

The adjustment for counterparty risk is the credit value adjustment. CVA is calculated as follows:

$$\text{CVA} \approx \text{LGD} \times \sum_{i=1}^{m} d(t_i) \times \text{EE}(t_i) \times \text{PD}(t_{i-1}, t_i)$$

where:
LGD = loss given default or how much of the exposure one expects to lose in the event of a counterparty default; equal to 1 minus the recovery rate (1 – RR)
EE = expected exposure for future dates
PD = marginal default probability
d(t) = discount factors or the risk-free rate component of the CVA at time *t*; future losses are discounted back to the present with these terms

Speed and simplicity are the hallmarks of this calculation, which aggregates components from different departments of the risk management organization. The resulting amount may be expressed as a percentage of the notional value of the transaction on which it is based. Additionally, the formula assumes no wrong-way risk and does not require simulation default events, which simplifies the calculation.

## CVA as a Spread

To approximate the CVA as a spread, divide the CVA by the unit premium of a risky annuity [e.g., credit default swap (CDS)] for the contract in question, producing an annual spread in basis points. This would be a charge to the weaker counterparty. The left-hand side of the following calculation represents the CVA as a running spread:

$$\frac{\text{CVA}(t,T)}{\text{CDS}_{\text{premium}}(t,T)} = X^{\text{CDS}} \times \text{EPE}$$

where:
$\text{CDS}_{\text{premium}}(t, T)$ = unit premium value of a credit default swap
$X^{\text{CDS}}$ = CDS premium at maturity date *T*; this amount can be thought of as a credit spread
EPE = expected positive exposure that is the average of the expected exposure over a preset time period, typically from the present to the maturity date of the transaction

Assumptions for this calculation include (1) EPE is constant over the entire profile, (2) default probability is constant over the entire profile, and (3) EE or default probability is symmetric over the entire profile.

**Example: Computing CVA spread**

A trader needs a quick approximation of the CVA spread on a swap. The exposure management group comes up with an EPE of 6%. The counterparty's credit spread is around 375 basis points (bps) per year. **Calculate** the CVA as a running spread.

**Answer:**

The CVA as a running spread would be computed as:

$$6\% \times 3.75\% = 23 \text{ bps}$$

This is the amount the trader may add to or subtract from the leg of the trade as the CVA or credit charge, and it is a common way to represent CVA as a risk charge to the client in a swap transaction.

## Impact of Changes in Credit Spread and Recovery Rates

### LO 31.4: Evaluate the impact of changes in the credit spread and recovery rate assumptions on CVA.

When evaluating the impact of the probability of default and recovery on CVA, the following factors must be considered: credit spread levels, the shape of the credit spread curve, the impact of the recovery rate, and the basis risk that arises between different recovery rate assumptions.

Regarding the impact of changes in the credit spread, the CVA will most often increase given an increase in the credit spread. However, the impact will not be linear because default probabilities are limited to 100%. If a counterparty is very close to default, the CVA will actually decrease slightly, and in default the CVA will fall to zero. When considering the shape of the credit spread curve, the CVA will be lower for an upward-sloping curve compared to a flat and a downward-sloping curve, and the CVA will be higher for a downward-sloping curve compared to a flat and an upward-sloping curve.

Regarding the impact of changes in recovery rate assumptions, increasing the recovery rate will increase the implied probability of default but reduce the resulting CVA. Differences in settled versus actual recovery rates may also be considered. The settled recovery is the recovery at default, while the actual recovery is the claim amount that will be received. As an example, consider a settled recovery rate of 10% and an actual recovery rate of 40%. In this situation, the higher actual recovery rate will produce a lower CVA compared to a 40% recovery assumption for both settled and actual recovery rates.

## Incorporating Netting and Collateralization

### LO 31.5: Explain how netting can be incorporated into the CVA calculation.

### LO 31.7: Explain the impact of incorporating collateralization into the CVA calculation.

**Netting** reduces the CVA price as it nets (i.e., reduces) exposure when trades are settled. One must evaluate the change in CVA before and after a trade has been executed. The new trade should be sufficiently profitable to offset any increase in CVA at a minimum. This expression is shown as follows:

$$V(i) = \Delta CVA_{NS,i} = CVA(NS, i) - CVA(NS)$$

where:
V(i) = risk-free value of new trade *i*
CVA(NS, i) = CVA included in new trade in the netting set
CVA(NS) = CVA on all current trades within the netting set

**Collateralization** reduces the CVA, changing only the counterparty's expected exposure (EE), but not its default probability. Inclusion of minimum transfer and threshold amounts would correspondingly increase the CVA as they increase exposure linearly.

## Incremental and Marginal CVA

### LO 31.6: Define and calculate incremental CVA and marginal CVA, and explain how to convert CVA into a running spread.

The practicality of CVA lies in its ability to take into account risk mitigation provided by collateralization and netting. The usefulness of standalone CVA is limited to giving the risk manager a quick appraisal of the CVA charge.

**Incremental CVA** is the change (or increment) in CVA that a new trade will create, taking netting into account (i.e., the difference between CVA with and without the new trade). The formula differs from the original CVA only in the change in expected exposure. The $\Delta$EE is the incremental change in EE at each point in time caused by the new trade, which impacts the original exposure.

Incremental CVA is important for pricing a new trade with respect to existing ones. CVA with netting will never be higher than CVA without netting because netting cannot increase exposure. The benefits of netting are a function of the transaction size. The larger the transaction, the smaller the benefit to the point where the value of incremental CVA will approach standalone CVA.

**Marginal CVA** enables the risk manager to break down netted trades into trade level contributions that sum to the total CVA. The calculation is identical to that for the standalone CVA, except for the substitution of marginal EE for initial EE. This metric

allows for more rigorous analysis, as it is useful for better understanding which trades have the greatest impact on a counterparty's CVA. It provides an ex-post view of the trades.

## Converting CVA into a Running Spread

Converting an upfront CVA into a running spread CVA is also worth considering. Given an interest rate swap, the rate paid on the swap would need to change when charging a CVA to a client. This transformation would occur by dividing the CVA by the risky duration for the maturity under consideration. For example, assuming a five-year payer interest rate swap with a notional amount of 100M, a risky duration of 3.75, and a standalone CVA of 90,000, the additional spread would be calculated as:

$$90{,}000 / (3.75 \times 100{,}000{,}000) = 2.40 \text{ bps}$$

However, the addition of this spread will also impact the CVA. Therefore, the correct value should be computed in a recursive fashion until the risky MtM value declines to zero. This is accomplished by solving the following equation: $V_{C'} = CVA_{C'}$, where $V_{C'}$ is the contract value given the adjusted rate $C'$. This method ensures that the CVA is offset by the initial value and allows the adjusted rate ($C'$) to become the hurdle rate for profitability.

## Applying CVA to Exotic Products and Path Dependency

Applying CVA to exotic products and in the presence of path dependency presents special challenges.

Regarding **exotic products**, valuation may require techniques such as Monte Carlo simulation. Thus, value approximations to such products may be necessary to estimate their CVA values given the complexity in pricing the products themselves (e.g., swaptions may be treated as forward swaps, Bermudan option payoffs may be treated as European option payoffs).

Regarding **path dependency**, in order to assess future exposure at a given point in time, one must have information on the entire path from the present to that future date. As with exotic products, approximation of the probability calculation of path-dependent events will suffice when dealing with exotic derivative prices.

# Key Concepts

## LO 31.1

Motivations for pricing counterparty risk include (1) organization of responsibilities within the institution with respect to the pricing calculation and (2) determining whether a trade is sufficiently possible when factoring in counterparty risk charge.

## LO 31.2

A credit value adjustment is the price of counterparty risk. A positive value is a cost to the counterparty bearing the risk. The basic CVA formula assumes no wrong-way risk.

## LO 31.3

CVA is calculated as follows:

$$\text{CVA} \approx \text{LGD} \times \sum_{i=1}^{m} d(t_i) \times \text{EE}(t_i) \times \text{PD}(t_{i-1}, t_i)$$

CVA as a spread is CVA divided by the risky annuity for the maturity of the contract in question, producing an annual spread or charge expressed in basis points:

$$\frac{\text{CVA}(t, T)}{\text{CDS}_{\text{premium}}(t, T)} = X^{\text{CDS}} \times \text{EPE}$$

## LO 31.4

Credit spread levels, the shape of the credit spread curve, the impact of the recovery rate, and the basis risk that arises from different recovery rate assumptions must all be considered when evaluating the impact of the default probability and recovery on CVA.

## LO 31.5

Netting reduces the CVA price because it nets exposure when trades are settled.

## LO 31.6

Incremental CVA is used to calculate the cost of a new trade versus an existing one to determine the effect that the new trade has on CVA. Standalone CVA cannot do this. The formula for the incremental CVA calculation is identical to that for standalone CVA, except for the incremental expected exposure.

Marginal CVA is used for trade level attribution (i.e., to discover the determinants of the CVA). The formula for the calculation of marginal CVA is identical to that for standalone CVA, except for the substitution of marginal expected exposure for expected exposure.

## LO 31.7

Collateralization reduces the CVA, changing only the counterparty's expected exposure.

## Concept Checkers

1. Which of the following statements is not a motivation for pricing counterparty risk?
   A. Accurate pricing should only account for the cost of the trade.
   B. Counterparty risk pricing should account for risk mitigants.
   C. Best practices organize pricing responsibilities in the organization.
   D. Pricing bilateral derivatives contracts.

2. With respect to the CVA calculation, which of the following statements is correct when a risk manager wishes to understand which trades have the greatest impact on a counterparty's CVA? The manager would use:
   A. incremental CVA because it accounts for the change in CVA once the new trade is priced, accounting for netting.
   B. marginal CVA because he could break down netted trades into trade level contributions.
   C. incremental CVA because he could break down netted trades into trade level contributions.
   D. marginal CVA because it accounts for the change in CVA once the new trade is priced, accounting for netting.

3. A trader wants to know the approximate CVA for a counterparty in a swap transaction. The counterparty's expected potential exposure (EPE) is 7%, and its credit spread is 475 basis points. What is the CVA as a running spread?
   A. 0.33%.
   B. 1.48%.
   C. 2.25%.
   D. 9.75%.

4. Regarding the impact of changes in the credit spread and recovery rate assumptions on the CVA, which of the following statements is true?
   A. A decrease in the credit spread will most often increase the CVA.
   B. For an upward-sloping curve, the CVA will be higher compared to a downward-sloping curve.
   C. Increasing the recovery rate will reduce the CVA.
   D. If the actual recovery rate is higher than the settled recovery rate, the CVA will most likely be higher compared to a situation where both recovery assumptions are the same for both rates.

5. When incorporating netting and collateralization into the CVA calculation, which of the following statements is incorrect?
   I. Netting increases the CVA price because it reduces exposure when trades are settled.
   II. Collateralization does not change the CVA because it only changes the counterparty's expected exposure.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

## Concept Checker Answers

1. **A** Accurate pricing should account for not only the cost of the trade, but also the cost of counterparty risk.

2. **B** Understanding which trades have the greatest impact on a counterparty's credit value adjustment requires use of the marginal CVA. Incremental CVA, by contrast, is useful for pricing a new trade with respect to an existing one.

3. **A** Calculation of the CVA as a running spread entails multiplying the counterparty's EPE by its credit spread:

   $7\% \times 4.75\% = 33$ bps

4. **C** Increasing the recovery rate will increase the implied probability of default but reduce the resulting CVA. The CVA will most often increase given an increase in the credit spread. When considering the shape of the credit spread curve, the CVA will be lower for an upward-sloping curve compared to a downward-sloping curve. Finally, a higher actual recovery rate will most likely lead to a lower CVA compared to a situation where the recovery assumptions are the same for both actual and settled rates.

5. **C** Both statements are incorrect. Netting reduces the CVA price as it reduces exposure when trades are settled. Collateralization also reduces the CVA, changing only the counterparty's expected exposure (EE), but not its default probability.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Wrong-Way Risk

Topic 32

## Exam Focus

The recent global financial crisis and European sovereign debt crisis illustrated the significance of wrong-way risk and right-way risk. For example, buyers of protection against bond defaults may witness an impressive gain in their position due to falling bond prices as a result of some macroeconomic events. However, at the same time, falling bond prices increase the risk exposure and default probability of a counterparty due to the adverse impact of macroeconomic events, resulting in an overall increase in counterparty risk. This is an example of wrong-way risk (WWR). Normal derivatives markets are characterized as possessing right-way risk (RWR), in which hedges produce successful expected results. Macroeconomic events affect risk exposure and default probability in a favorable manner such that the overall expected counterparty risk declines. For the exam, be able to explain both wrong-way risk and right-way risk as well as identify these risks in transactions such as put options, call options, credit default swaps, foreign currency transactions, interest rate and currency swaps, and commodities.

## Wrong-Way Risk vs. Right-Way Risk

### LO 32.1: Describe wrong-way risk and contrast it with right-way risk.

**Wrong-way risk** (WWR) is an outcome of any association, dependence, linkage, or interrelationship between exposure and counterparty creditworthiness that generates an overall increase in counterparty risk and, therefore, an increase in the amount of the credit value adjustment (CVA). WWR also results in a reduction of the debt value adjustment (DVA). WWR can be hard to determine due to difficulties assessing the relationship among variables and the lack of relevant historical data.

**Right-way risk** (RWR) is just the opposite of WWR. That is, any dependence, linkage, or interrelationship between the exposure and default probability of a counterparty producing an overall decrease in counterparty risk is described as RWR. RWR decreases the CVA and increases the DVA.

It is also worth mentioning that WWR has been the center of attention in historical context, while RWR has been paid relatively little attention. However, both risks are important, and financial institutions should strive to increase RWR and decrease WWR.

Another way to contrast WWR and RWR is to think that "normality" in derivatives markets is an example of RWR. That is, derivatives transactions produce intended results if the market is functioning in an expected manner. For instance, a coffee producer would sell (i.e., short) forward or futures contracts in order to protect against the downside risk of falling prices in the future, and a textile owner (that manufactures cotton cloth) would go

long in cotton derivatives contracts if she anticipates a rise in cotton prices. Thus, RWR produces a favorable relation between default probability and exposure, reducing overall counterparty risk. Hedges, in normal functioning markets, should automatically generate RWR because the fundamental purpose of hedges is to curtail counterparty risk.

*Professor's Note: We are using derivatives markets just for illustration of wrong-way and right-way risks. By no means are these risks confined only to derivatives.*

Markets and numerous interactions (e.g., market credit interaction) do not always produce normal behavior, as evidenced by the recent global financial crisis. Those who were seeking protection against the default of debt issuers (e.g., on collateralized debt obligations) became victims of WWR when unfavorable interaction between exposures and insurers' default probabilities (which were supposed to provide protection) intensified the amount of counterparty credit risk.

The amount of counterparty risk is roughly equal to the product of exposure and the counterparty's default probability at a specified loss rate given default. Counterparty risk is a kind of credit risk that is estimated as loss reserve for loans, and in over-the-counter (OTC) derivatives markets, it is similar to estimating loan reserves.

Loan exposure, however, is normally assumed to be a fixed amount for a specified time period, whereas in OTC derivatives, the exposure fluctuates depending on market conditions. An example of WWR (RWR) would be a change in exposure and counterparty credit quality, producing an unfavorable (favorable) dependence in exposure and counterparty credit quality and resulting in an increase (decrease) in the amount of overall counterparty risk. The change in exposure and credit quality could be due to numerous external factors such as interest rates, inflation, exchange rate movements, and global events. Note that credit quality increases actually increase WWR. This is because counterparties with high credit quality are less likely to default. As a result, the occurrence of a default by a counterparty with high credit quality is less expected than a default by a counterparty with low credit quality.

## Examples of Wrong-Way Risk and Right-Way Risk

### LO 32.2: Identify examples of wrong-way risk and examples of right-way risk.

For this LO, we'll create a few hypothetical examples of WWR and RWR. For example, what if Company XYZ (the borrower) and the guarantor on XYZ's loan, Company ABC, share ownership in a business (or are in the same industry)? Due to some market or economic factors, both may default together (WWR), whereas if the guarantor and the borrower are not in the same industry (nor have shared ownership), XYZ's loan guarantee may still be valid, even if XYZ defaults (RWR).

What if ABC has sold protection much higher than its capital in a concentrated area (business or industry) and XYZ has bought protection (insurance) from ABC? Macro factors may increase the "exposure" for the guarantor (ABC), and due to positive interaction between exposure and credit quality, the overall counterparty (guarantor) risk increases to

the extent that XYZ's protection becomes meaningless (WWR). In contrast, the reverse of the situation may generate a favorable state—an increase in exposure may be sufficiently offset by an increase in creditworthiness.

The CVA, which is based on the amount of counterparty risk, is generally approximated by the product of exposure and the default probability of the counterparty (for a given recovery rate). This estimation is based on an underlying assumption that these events are independent. However, they may not be independent (as evidenced in the recent financial crisis). Unfavorable (favorable) association between default probability (credit risk) and exposure (market risk) may produce WWR (RWR), increasing (decreasing) the overall CVA.

Quantifying WWR and RWR involves estimation of the CVA based on expected exposure, conditional on counterparty default (under the more realistic scenario of the presence of interconnected markets with systemic risk), whereas under the independence assumption, we use unconditional default probability.

It is estimated that conditional expected exposure will increase if the exposure (e.g., value of a forward contract) and the default probability of the counterparty are positively correlated, exhibiting WWR. On the other hand, negative correlation in this instance will lower the conditional expected exposure, showing RWR.

As discussed earlier, the overall counterparty risk stems from a situation in which the counterparty credit quality is linked with macro (and global) factors that also impact the exposure of transactions. The transaction can be any of the following: put options, call options, foreign currency transactions, forward contracts, credit default swaps, or interest rate and currency swaps. Let us examine WWR and RWR as they relate to some of these transactions.

## Over-the-Counter Put Option

A put option gives the right to the long (buyer) to sell an underlying instrument at a predetermined price whereas the short (counterparty) is obligated to buy if the option is exercised. Out-of-the money put options have more WWR than in-the-money put options.

Macroeconomic events (such as interest rates, inflation, industry- and sector-specific factors, or global factors) may deteriorate the creditworthiness of the counterparty, increasing the default probability. The same factors may trigger a fall in the underlying (e.g., stock) asset's price, generating positive payoffs for the long but increasing the counterparty risk exposure. Before the long gets too excited to see an increase in payoffs, he is hit by the realization of increasingly becoming a victim of WWR, due to positive correlation between the risk exposure of the counterparty and probability of default of the counterparty producing an overall increase in counterparty risk. The payoffs may not materialize, although they are increasing. On the other hand, normalcy of the transaction would be termed as RWR if the counterparty is able to fulfill its obligation despite an increase in its position obligation.

*Professor's Note: We are assuming in the previous put option example that the counterparty and the underlying issuer are the same in order to clearly illustrate WWR. The positive association between default probability and exposure will still give rise to WWR if the counterparty and underlying issuer are not the same.*

## Over-the-Counter Call Option

A call option gives the right to the long (buyer) to buy an underlying instrument at a predetermined price whereas the short (counterparty) is obligated to sell at the agreed-upon price if the option is exercised. Like the put option, we are assuming the counterparty and the underlying issuer are the same.

Assume that due to changes in some macroeconomic and global factors, the default probability of the counterparty declines, and the price of the underlying asset (e.g., stock) increases, producing higher payoffs for the call buyer. In this instance, his excitement of making money will be appropriate because the counterparty will be in a strong position to pay off its obligation (due to the overall increase in creditworthiness). Such an outcome will be considered the "normalcy" of the transaction, and it is termed RWR. The short is able to fulfill its obligation despite the increase in its position obligation. On the other hand, if the counterparty is unable to fulfill its obligation due to the increase in its position obligation (higher value of underlying for the long, but higher obligation for the short—an increase in counterparty risk exposure), it would be an example of WWR (from the standpoint of the long position).

## Credit Default Swaps (CDSs)

The 2007–2008 credit crisis offers a classic example of WWR from the perspective of the longs (i.e., the buyers) who had bought protection on issuers default on collateralized debt obligations (CDOs) or bonds backed by mortgage-backed securities (MBSs) via credit default swaps (CDSs).

As the real estate bubble burst and the market started taking a downward freefall, the value of MBSs started exhibiting a freefall as well. The monoline insurers, such as AMBAC and MBIA, had taken highly concentrated positions in offering protection against MBSs and CDOs. As the issuers of MBSs and CDOs started defaulting, the insurers were flooded by claims from the ones who had bought the protection (i.e., holders of CDSs).

The value of CDSs was rising, but this gain was generating an increase in risk exposure to the counterparty. Both the probability of default and the risk exposure of the insurers were rising. The unfortunate buyers of protection soon found out that the macrocredit and exposure linkage had produced unfavorable results for them. Despite huge gains on their positions, nothing materialized due to the deteriorating creditworthiness of the issuers, an example of WWR.

The normalcy of the transaction would be if the counterparty could fulfill its obligation despite an increase in position exposure (perhaps due to a negative association between risk exposure and probability of default). This would be an example of RWR. If insurance

company ABC, for example, had taken a nonconcentrated exposure, it might not have experienced a decline in its creditworthiness (due to fewer claims) and would have been able to satisfy its obligations despite increasing risk exposure in the CDSs.

### Foreign Currency Transactions

Consider a commercial bank in a developed economy (e.g., the United States) that enters into a cross currency agreement with a commercial bank (counterparty) in an emerging market (e.g., Uzbekistan), under which the counterparty will deliver developed market currency in return for local currency.

Macro conditions in the emerging country, such as a sovereign debt crisis, generate credit stress for the local bank, as well as a decline (depreciation) of local currency. The value of the transaction increases substantially for the financial institution in the developed economy due to the declining currency of the emerging economy. At the same time, the counterparty risk exposure increases as the gain for the financial institution in the developed economy increases.

Increases in default probability (due to credit stress) and risk exposure (due to declining currency) increase counterparty risk, resulting in WWR for the financial institution in the developed economy.

If the counterparty risk exposure and the credit quality are not unfavorably associated, then the risk exposure may increase, but the probability of default may decline (due to improvement in creditworthiness), producing a reduction in overall counterparty risk. This would be an example of RWR.

### Foreign Currency Swaps

A real-world example will further clarify WWR in the foreign currency swaps market. Prior to the recent credit crisis in the United States, numerous financial institutions in Japan had entered into swap agreements with U.S. financial institutions to obtain dollar funding by using yen. They pledged yen to get U.S. dollars. After the default of Lehman Brothers, the financial crisis reached its peak, raising grave concerns about the economic slowdown of the U.S. and European economies. The yen significantly appreciated against the U.S. dollar, resulting in a substantial gain to Japanese bank positions (the pledged yen will buy more dollars, and U.S. banks will have to surrender more dollars for the pledged yen), increasing the counterparty risk exposure for Japanese banks. At the same time, deteriorating macro conditions had a negative impact on U.S. banks and the economy. In addition, the default probabilities of the U.S. financial institutions increased. Positive (unfavorable) association between counterparty risk exposure and default probability generated an overall increase in counterparty risk for Japanese banks, and they experienced WWR.

If the risk exposure and default probabilities are not positively associated, the normalcy of the transaction would balance out the increase in risk exposure by improving the creditworthiness of the financial institutions (macro factors may be related to both events in a different manner), lowering overall counterparty risk. The counterparty is able to meet its obligation despite an increase in risk exposure (due to an appreciating yen). This would be an example of RWR.

## Interest Rate Transactions

Interest rate swaps provide another good illustration of WWR. In an interest rate swap, one party (i.e., the long or fixed-rate receiver) enters into an agreement with a counterparty (i.e., the fixed-rate payer) to receive a fixed rate and pay a floating rate. The fixed-rate receiver gains if the market interest rate (the swap rate) falls.

Assume due to macroeconomic conditions (e.g., an economic downturn), policy interest rates are lowered. The fixed-rate receiver experiences a value gain to the extent that the swap rate declines against the counterparty with the fixed-rate payer and floating-rate receiver. However, this gain for the fixed-rate receiver also produces an increase in its counterparty risk exposure. Furthermore, if the economic downturn would also increase the default probability, then overall counterparty risk will increase, generating WWR for the fixed-rate receiver.

This is exactly what happened during the recent European sovereign debt crisis. Due to lower inflation and an economic recession, the policy interest rates were lowered. The euro (interest rate) swap rate declined, producing a gain for those who were holding fixed interest rate receiver positions against Italian financial institutions (fixed-rate payer). However, the decline in the euro swap rate also increased the counterparty risk exposure. Deteriorating economic conditions also increased the default probability of Italian financial institutions. An increase in both the risk exposure and default probability resulted in an overall increase in counterparty risk, generating WWR for the holder of fixed-rate receiver swaps.

In the absence of a positive association between risk exposure and default probability, the Italian financial institutions might have been able to fulfill their obligations comfortably, despite the increase in exposure, generating RWR.

## Commodities

Airlines hedge against the risk of rising oil prices. For example, assume an airline is long an oil forward contract at a fixed price. The counterparty is a dealer who has taken heavy concentrated positions. If oil prices rise, the gains for the airline will rise. The airline will buy cheap oil because the spot price will be higher than the locked-in forward price, but at the same time, the risk exposure for the dealer will increase. Because the dealer had concentrated positions, there may be a flood of claims (several forward contract claims brought by various airlines), putting intense pressure on the credit quality of the counterparty. Thus, an increase in both the risk exposure and the default probability will increase overall counterparty risk, producing WWR.

On the other hand, a dealer with a nonconcentrated position may continue to have sound creditworthiness despite rising exposure. Thus, the dealer will be able to fulfill her obligation, lowering the overall expected amount of risk exposure from the standpoint of the airline. This would be an example of RWR.

## Key Concepts

### LO 32.1

Financial institutions should pay more attention to wrong-way risk and right-way risk for planning purposes. The recent global financial crisis and European sovereign debt crisis have illustrated the significance of these risks.

Numerous macroeconomic events can impact exposure risk and default probability, producing an overall increase in counterparty credit risk. Position gains may not materialize due to an increase in the counterparty's overall risk. This is an example of wrong-way risk.

On the other hand, favorable associations between exposure risk and default probability resulting from changes in macro factors may produce a decline in overall counterparty credit risk. This is an example of right-way risk.

### LO 32.2

Wrong-way risk and right-way risk can be identified in numerous investment products and transactions, such as call options, put options, credit default swaps, foreign currency transactions, interest rate products, currency swaps, and forward contracts.

The key to identify wrong-way and right-way risk is to assess the impact on overall counterparty risk. If the co-movement between risk exposure and default probability generates an overall increase (decrease) in counterparty risk, it would be an example of wrong-way risk (right-way risk).

During the recent global financial crisis, credit default swaps offered a classic example of wrong-way risk. The buyers of credit default swaps (protection against the default of bond issuers) experienced a substantial gain as the values of the bonds backed by mortgage-backed securities started tumbling. However, the collapse of the mortgage market not only increased the risk exposure but also the default probability, leading to an overall increase in counterparty risk. There were many buyers of credit default swaps whose gains remained paper gains due to the deteriorating creditworthiness of the counterparty.

## Concept Checkers

1. How many of the following statements regarding wrong-way risk (WWR) and right-way risk (RWR) are correct?
   I. Co-movement in risk exposure and default probability producing a decline in overall risk is an example of wrong-way risk.
   II. Co-movement in risk exposure and default probability producing an increase in overall counterparty risk is an example of right-way risk.
   III. Co-movement in risk exposure and default probability producing neither a decline nor an increase in the overall counterparty risk is an example of wrong-way risk.
   IV. Co-movement in risk exposure and default probability producing a decline in risk exposure but an increase in counterparty default probability is an example of right-way risk.
   A. None.
   B. All.
   C. Two.
   D. Three.

2. Which of the following events would likely lead to an increase in WWR?
   I. The borrower and the guarantor are business partners.
   II. A monoline insurer sold protection concentrated in a business or industry.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

3. Which of the following statements regarding WWR and RWR is correct?
   A. A long put option is subject to WWR if both risk exposure and counterparty default probability decrease.
   B. A long call option experiences RWR if the interaction between risk exposure and counterparty default probability produces an overall decline in counterparty risk.
   C. Declining local currency can decrease the position gain in a foreign currency transaction, while increasing risk exposure of the counterparty.
   D. The 2007–2008 credit crisis provides an example of WWR from the perspective of a long who had sold credit default swaps (CDSs) as protection against bond issuers' default.

4. How many of the following statements regarding counterparty risk are correct?
   I. Speculation in normal-functioning derivatives markets automatically produces RWR.
   II. RWR has been the center of attention in historical context, whereas WWR has not been paid much relative attention.
   III. The counterparty default probability does not enter into the equation for estimating the overall counterparty risk.
   IV. Unlike exposure to OTC derivatives, which is normally assumed to be a fixed amount for a specified time period, exposure to bank loans fluctuates depending on market conditions.
   A. None.
   B. All.
   C. Two.
   D. Three.

5. Which of the following statements is correct?
   I. Depreciation of the yen after the default of Lehman Brothers gave a substantial gain to Japanese bank foreign currency swaps positions to obtain dollar funding in interest rate swaps.
   II. Fixed-rate receivers experience a value gain to the extent that the swap rate increases.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

## Concept Checker Answers

1. **A** A decline in overall counterparty risk is an example of right-way risk. An increase in overall counterparty risk is an example of wrong-way risk. An increase in overall counterparty risk is a condition for the emergence of wrong-way risk. A decline in risk exposure but increase in counterparty default probability may or may not lower overall counterparty risk.

2. **C** WWR will increase if the borrower and guarantor are business partners. The guarantees offered by a monoline insurer may turn out to be worthless if the risk exposure increases and the guarantor is hit by a flood of claims due to a concentrated position in an industry or business.

3. **B** A long call option experiences RWR if risk exposure and counterparty default probability results in decreased counterparty risk. A long put option is subject to WWR if both risk exposure and counterparty default probability *increase*. Declining local currency can *increase* the position gain in a foreign currency transaction, while increasing counterparty risk exposure. The 2007–2008 credit crisis provides an example of WWR from the perspective of a long who had *bought* CDSs as protection against bond issuers' default.

4. **A** Hedging, and not speculation, in normal functioning markets automatically produces RWR. Historically, RWR was relatively neglected by institutions for planning purposes. The counterparty default probability is one of the key elements in estimating overall counterparty risk. OTC exposures fluctuate based on market conditions.

5. **D** Appreciation, and not depreciation, of the yen generated a substantial gain for Japanese banks with foreign currency swaps positions. A fixed-rate receiver experiences a value gain to the extent that the swap rate declines.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Credit Derivatives and Credit-Linked Notes

Topic 33

## Exam Focus

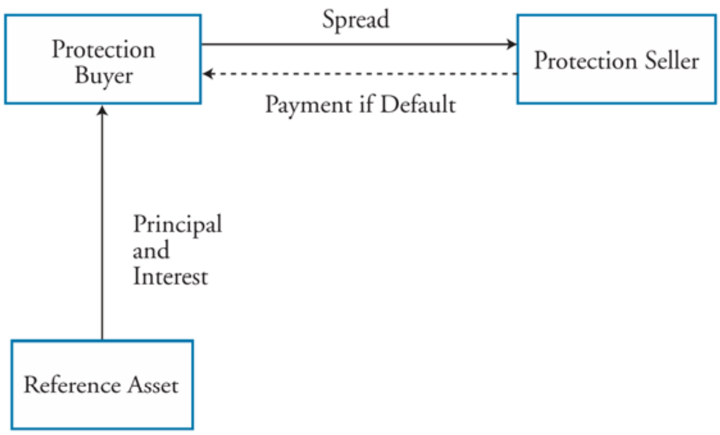
This topic examines the world of credit derivatives. It is important to understand the structure of credit default swaps (CDS), baskets, and indices. The most fundamental security, and building block for all credit derivatives, is the CDS. The CDS is similar to an insurance contract whereby the protection buyer makes premium payments to the protection seller in exchange for a contingent payoff in default or other credit event. Many variations on CDS exist including asset default swaps, equity default swaps, total return swaps, and credit-linked notes. Understand the differences in payouts and risk transfer between standard, nth-to-default, first-to-default, and senior and subordinated baskets.

## Credit Default Swaps

### LO 33.1: Describe the mechanics and attributes of a single named credit default swap (CDS).

A single-name **credit default swap** (CDS) is a bilateral derivative contract between a protection buyer and a protection seller. Although named a "swap" the security is a contingent claim and, hence, functions like a put option. The protection buyer will make pre-specified payments to the protection seller over a pre-specified time period and the protection seller is liable for making the protection buyer "whole" if a credit event occurs. Hence, a single-name CDS operates essentially as an insurance contract but a key difference is that the protection buyer need not actually own the underlying asset. Figure 1 illustrates the mechanics of the single-name CDS.

**Figure 1: CDS Structure**



In option terminology, the protection buyer (long put) is short the credit risk and pays the premium or **CDS spread** (up front or "running" over time) to the protection seller (short put) who is long the credit risk. If there is no credit event by contract expiration, the protection buyer loses the premiums paid. On the other hand, if there is a credit event during the term of the contract, the protection seller will make a contingent payment to the protection buyer. Thus, a **credit event** is analogous to exercising an in the money put option.

It is the responsibility of the protection seller to compensate the protection buyer for a credit event (we will formally discuss what constitutes a credit event shortly). There are two standard settlement methods: cash settlement or physical settlement. Under **cash settlement**, the protection seller will make a one time cash payment to the protection buyer in the amount of par minus price after credit event (i.e., par minus current market price). On the other hand, if the contract specified **physical settlement**, the protection buyer delivers the underlying reference to the protection seller and receives a cash payment equal to the par value. Note that both methods of settlement are economically equivalent because the protection buyer is made whole.

Alternatively, the protection buyer may enter into a **digital swap** where the payout is binary. That is, the payment from a credit event is fixed and known in advance, independent of the actual impairment. Therefore, it is possible that the protection buyer will not be made whole. On the other hand, if the post-default amount is sufficiently high, the payout on the digital swap may exceed the economic loss on the bond (par minus price after credit event). Hence, a digital swap is a special type of cash settlement. Figure 2 summarizes the relationship between CDS and put options.

**Figure 2: Credit Default Swaps vs. Put Options**

| | *CDS* | *Put Option* |
|---|---|---|
| Term | known expiration | known expiration |
| Premium | up front or running | up front |
| Underlying | reference name | stock, index, etc. |
| Payment Trigger | credit event | in the money |
| Payoff | par – market value (standard CDS) | X – S |
| Fixed Payoff | digital swap | binary option |

Credit default swap contracts must specify the underlying reference in advance so both parties will agree when a credit event has occurred. The CDS will typically specify the **reference name**, which is the specific issuer or obligor of the underlying asset. The terms of the contract may be narrowed to specific assets or issues as agreed upon by both parties.

Ownership, recovery rights, and liquidity concerns are issues that may arise after a credit event. The key difference between CDS and traditional insurance is that under a standard insurance contract, the insured must own the underlying asset that is being indemnified, whereas the protection buyer in the CDS may or may not own the underlying. First, assume the protection buyer owns the underlying asset, and the reference name experiences a credit event. Under physical settlement, the protection buyer delivers the underlying reference, thereby removing itself from the asset recovery process. Hence, the protection seller receives the recovery rights as it is the legal owner of the reference. On the other hand, if the contract specifies cash settlement the protection buyer retains the recovery rights as the owner of the reference.

Alternatively, the protection buyer may not actually own the underlying reference. If the contract calls for physical settlement, the protection buyer will need to purchase the reference in the open market. Therefore, the short credit position will bear the risk of illiquidity in the secondary market for defaulted debt.

When comparing a CDS to bonds, a difference arises regarding payments before and after default. In case of default, the protection seller in a CDS has received premiums at least until the event date. On the other hand, bondholders have no guarantee of receiving accrued interest following a default.

Another critical component of the CDS contract is the a priori definition of "credit event." The International Swaps and Derivatives Association (ISDA) Master Agreement provides great flexibility in triggering payments from the protection seller to the protection buyer. The definition of credit event spans a spectrum of "hard" events, such as failure to pay principal/interest or filing for bankruptcy, to "soft" events, such as insolvency, downgrades, and repudiation of the obligation. Typically, the contract will impose a materiality clause so that a small failure to pay does not constitute a credit event. Finally, the most contentious potential credit event is the restructuring of the existing debt claim. Restructurings are not easily defined but tend to relieve the debt burden of the borrower by extending maturity and/or reducing periodic interest payments. Clearly, protection buyers would like this to be considered a credit event while protection sellers would not, which clarifies the importance of proper documentation for a CDS contract.

## Portfolio Credit Default Swaps

### LO 33.2: Describe the mechanics and attributes of portfolio CDS.

Portfolio products, in the most general sense, provide protection against one or more defaults on a pre-specified set of single-name credits. There are several important variations on the portfolio structure depending on whether the protection buyer seeks payout from each default (i.e., basket CDS), only on the *n*th default, only after a certain loss level is breached (i.e., senior basket), or only up to a certain loss level (i.e., subordinated basket).

In a **standard basket CDS**, the protection buyer will receive compensatory payout for each and every default. Because, in theory, the protection buyer can receive payments equal to the basket size, the spread is likely to be prohibitive. Rather, the buyer will specify some subset of loss events it wants to protect against.

A common basket structure is the ***n*th-to-default basket**, whereby the protection buyer fully absorbs the first *n*-1 defaults and only receives a compensatory payout on the *n*th default. Consider a bank that has set aside capital reserves to cover *n*-1 defaults but may seek additional protection by purchasing protection via *n*th-to-default basket.

In a **first-to-default basket**, the protection buyer will receive a compensatory payment from the first default regardless of the name or size. Because the basket will only pay on the first default, the structure terminates after the first credit event.

Similarly, the second-to-default basket will provide compensatory payment for the second default in the reference names (no payment is made from the first default). This basket structure is much more interesting because of the important role correlation will play in the pricing of the CDS spread. For example, suppose two credits are highly correlated (e.g., from exposure to the same macro industry factor). A default in one credit is likely to be followed with a default in the other credit. Hence, the payoff on the basket is more likely than if all the credits were independent.

*Professor's Note: Default correlation plays an important role in a basket CDS. If the reference assets are perfectly correlated, the payoff of the first-to-default CDS will be the same as the nth-to-default CDS. In a basket with many assets (e.g., 100), the payoff to junior tranche investors (e.g., risk of defaults 1 through 5) will be higher than senior tranches when the default correlation is low. This is due to an increased probability of only a small number of defaults. With low correlation between assets, there is a likely chance that 1 to 5 defaults will occur out of 100 assets. Under the perfect positive correlation scenario, the number of defaults will likely be either 0 or all 100 assets.*

**Senior baskets** and **subordinated baskets** payoff functions are a bit different than the previous basket structures. Whereas the standard and *n*th-to-default basket payoffs are based on the number of defaults, the senior and subordinated basket payoffs are a function of the cumulative loss level. Specifically, the senior basket will not receive any compensatory payment until a pre-specified loss level is reached. This concept is analogous to insurance proceeds above the deductible in a standard insurance policy. On the other hand, the subordinated basket will receive compensatory payments for cumulative losses below the pre-specified loss level. Hence, the subordinated basket payout represents the deductible in a standard insurance contract.

**Example: Basket credit default swap payoffs (Part 1)**

High Flying Hedge Fund has bought protection against five single names each with a notional principal of $10 million. The protection will cover the next year and then will expire. Over the next year, assume that each single named credit defaults and all currently trade at 40% of notional value (post default). **Calculate** the payoffs under the following structures: first-to-default, second-to-default, and standard basket CDS (assume the payoffs are settled with cash).

**Answer:**

Because each credit's post-default price is 40% of notional value, the compensatory payment is: 60% × $10 million = $6 million per credit.

- First-to-default: Because the basket will only pay for the first default, the total payout is $6 million.
- Second-to-default: Under a second-to-default basket the first default is unpaid. On the occurrence of the second default a payment of $6 million is triggered and the structure ends.
- Standard basket: In a standard basket, all defaults are paid so the total compensatory payment = 5 × $6 million = $30 million.

**Example: Senior and subordinated basket payoffs (Part 2)**

Suppose High Flying Hedge Fund is considering both a senior and subordinated basket with loss level set at $20 million. **Calculate** the payoffs of these two structures, assuming the same default pattern occurs as displayed in the previous example.

**Answer:**

Subordinated basket: A subordinated basket will pay a maximum of $20 million in payments. Because the total portfolio loss exceeds $20 million, the cap is reached and High Flying will only receive the maximum $20 million amount.

Senior basket: The senior basket structure triggers a payment once the loss level is exceeded. Because the total loss for the portfolio is 5 × $6 million = $30 million, the basket will receive a compensatory payment of $10 million, the excess loss above the threshold ($20 million).

## CDS Indices

### LO 33.3: Describe the composition and use of CDS indices.

Any CDS index is just a special case of the more general basket structure. The typical index will be equally weighted and differ only by its constituents. In 2004, the existing index providers decided to join forces and established the Dow Jones iTraxx CDS index. The increasing popularity of credit derivatives and the index structure has led to many new regional indices (North America, Europe, Asia), subindices, and other variations. Two popular indices include the HiVol index (30 widest trading credits in iTraxx Europe CDX index) and crossover index (ratings no higher than BBB–).

The broadest iTraxx indices include 125 equally weighted credits based on a polling of market participants. The indices have finite lives (5 or 10 years, typically) and then terminate. In addition, a new series will "roll" every 6 months so that there are several indices, perhaps with different constituents, trading at the same time.

It is important to note that these indices represent tradable products and not just benchmarks. As investors sought broad credit exposure beyond just single names, the demand for indices has increased dramatically.

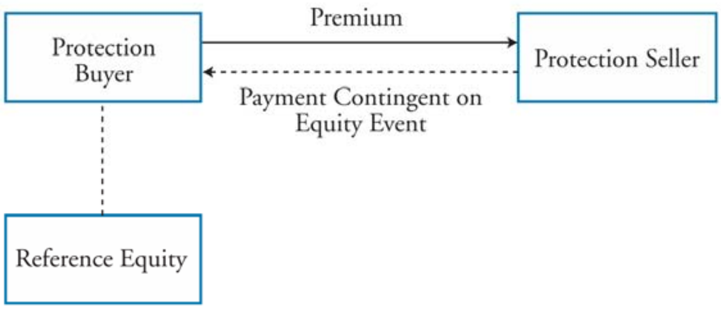
## Variations of Credit Default Swaps

**LO 33.4: Describe the mechanics and attributes of asset default swaps, equity default swaps, total return swaps and credit linked notes.**

An **asset default swap** functions as a single-name CDS where the underlying reference is an asset-backed security (ABS) as opposed to a specific reference. The market for ABS CDS has increased substantially as of late.

An **equity default swap** clearly implies that the buyer is seeking protection on an equity security. Of course, equity cannot default by definition, but rather the security provides a compensatory payout if the stock value falls below a pre-specified level (e.g., 70% of current value). Hence, the equity default swap closely resembles a deep out of the money put. Alternatively, the payout could be binary, effectively fixing a recovery rate of X%. For example, if the fixed recovery rate is 40%, then (100 – 40)% will be the compensatory payment in an equity event.

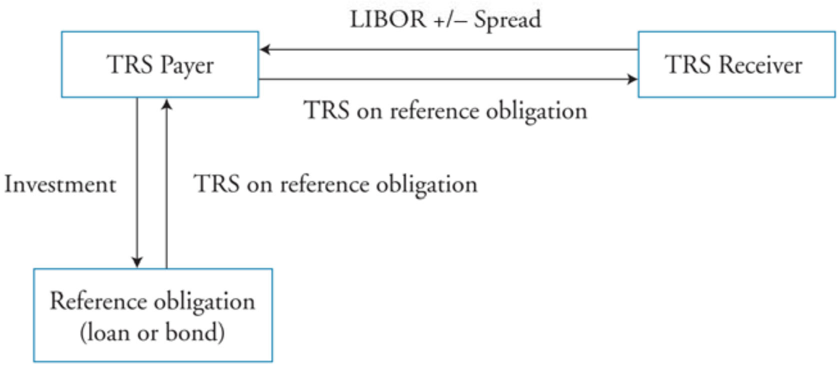
**Figure 3: Equity Default Swap Structure**




In a **total return swap**, one party will typically pay LIBOR plus a spread in exchange for the total return on an asset or reference portfolio for a stated notional principal (see Figure 4). The total return consists of all cash flows (dividends, coupons, etc.) and the percent change in asset value. Intuitively, if the protection seller is receiving all of the associated return with the reference asset(s), it must also be bearing all of its risk. Unlike a CDS where the protection seller is liable for credit events only, the total return swap receiver bears all risks (downgrade, market risk, interest rate risk, etc.), not just credit risk.

The specific contract must delineate the important terms including notional principal, reference asset/basket, method to determine value of reference asset/basket, et cetera, analogous to the CDS contract.

**Figure 4: Total Return Swap Structure**




**Example: Total return swap payoff**

High Flying Hedge Fund will enter into a $100 million total return swap on the S&P 500 Index as the index receiver (i.e., total return receiver). The counterparty (i.e., total return payer) will receive 1-year LIBOR + 400bp. The contract will last two years and will exchange cash flows annually. Given the following information, **determine** the cash flows at contract initiation, in one year, and in two years. Assume LIBOR remains flat.

- Current LIBOR = 5%.
- Current S&P 500 value = 1,000.
- S&P 500 in 1 year = 1,200.
- S&P 500 in 2 years = 900.

**Answer:**

Similar to other over-the-counter (OTC) contracts such as swaps and forwards, no cash flows are exchanged at initiation.

Over the next year, the S&P 500 Index will increase by 20%. Hence, the index receiver (High Flying) will receive $20 million from the index payer and will pay $9 million (LIBOR = 5% + 400bp) to the counterparty. Therefore, the net cash flow will be $11 million to High Flying.

Between years 1 and 2, the S&P 500 Index will drop 25%. Now, High Flying as the total return receiver must *pay* 25% to the counterparty in addition to the 9% floating rate. Hence, the total outflow from High Flying to the counterparty is $34 million.

The previous example illustrates a very interesting feature about total return swaps. We note that when the asset/reference return is negative, the total return receiver must make *two* payments to the total return payer: (1) interest payment based on LIBOR and (2) the negative return on the asset/reference.

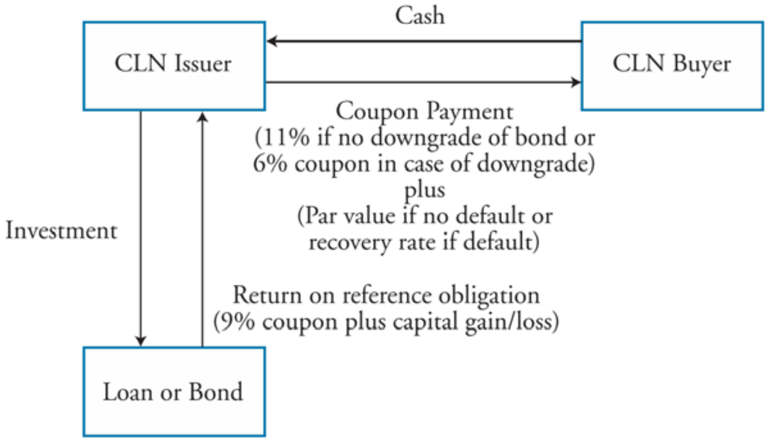
The final structure discussed here is the **credit-linked note** (CLN). The easiest way to understand a CLN is to view it as a straight bond with an embedded credit default swap on the bond issuer. Hence, the issuer of the CLN is the protection buyer, and the note holder is the protection seller. In return for bearing the credit risk, the note holder receives an

enhanced coupon. However, if a credit event occurs, the issuer may withhold interest and/or principal.

The CLN is fundamentally different from the single-name CDS contract because the note holder has already advanced the funds to the protection buyer via the principal payment. In addition, the CLN is still a bond and must be marketed to investors via a formal procedure.

The structure of a CLN is best understood by reference to the example in Figure 5. In Figure 5, the CLN issuer has bought a bond that pays a coupon of 9%. The issuer then pays a coupon of 11% to the CLN buyer in return for a cash investment. The 11% coupon is in effect unless there is a credit downgrade. In the event of a downgrade, the CLN issuer pays a lower coupon of 6% to the CLN buyer. If there is no default, the issuer pays par at maturity of the note. If there is a default, the issuer pays the recovery rate (the amount recovered from the issuer of the defaulted note).

**Figure 5: The Structure of a Credit-Linked Note**




The *benefit* to the CLN issuer is that if there is a credit downgrade but no default, the issuer makes a spread of 3% (9% – 6%). Additionally, the issuer has transferred the credit and default risk of the bond to the CLN buyer. The cost of this transfer is the higher yield (11% versus 9%) if there is no downgrade. If there is a default, the CLN issuer owes the CLN buyer only the recovery rate. Note that the CLN issuer has no counterparty risk because the issuer has purchased the bond.

An alternative to unloading the credit risk of the bond would be for the CLN issuer to buy a credit default swap, which was discussed previously. Note, however, that in the default swap, the buyer does have counterparty risk. Because the CLN issuer has no counterparty risk, the yield that must be paid in a CLN is usually higher than that in a default swap.

The *benefit* to the CLN buyer is that the buyer earns a high return if there is no downgrade. It is also the case that CLNs allow investors who are restricted from buying derivatives to invest in synthetic security. The buyer's primary *risk* is that there is a downgrade or default and that the buyer earns a lower return. Second, the buyer has counterparty risk because the CLN issuer could default on its obligation. There is also correlation risk if the default risks of the CLN issuer and bond issuer are highly correlated. The stronger the correlation, the higher return the CLN buyer should expect. Finally, CLNs are often privately traded and illiquid, so CLN investors may have a difficult time redeeming them prior to maturity.

## Key Concepts

### LO 33.1

Credit default swaps are the building block to many other credit derivatives. In the basic contract, the protection buyer will pay premiums to the protection seller in exchange for a contingent payoff upon a credit event. A credit event may be failure to pay, bankruptcy, or downgrade, and settlement may be cash or physical.

### LO 33.2

Portfolio products combine multiple credit references whose payoff depend on how many and/or how large the defaults. First-to-default baskets will only payout for the first default. Senior baskets will make a contingent payment once a pre-specified loss level is reached while subordinated baskets will provide protection only to the pre-specified loss level. Standard baskets will pay each default in full.

### LO 33.3

Indices provide easy access to the credit markets by purchasing or selling protection on an equally weighted basket. Many indices based on geography and credit ratings exist.

### LO 33.4

Variations of the CDS to other underlying securities include asset default swaps (CDS on ABS) and equity default swaps (CDS on equity performance). Total return swaps will exchange floating cash flows for total return on an asset/reference. In contrast to CDS, the total return swap receiver bears all risk, not just credit risk. CLN is a form of funded credit protection from embedding a CDS into the bond issue. The note holder receives an enhanced coupon to compensate for bearing the credit risk of the issuer.

## Concept Checkers

1. You are currently long $10,000,000 par value, 8% XYZ bonds. To hedge your position, you must decide between credit protection via a 5-year CDS with 60bp annual premiums or digital swap with 50% payout with 50bp annual premiums. After one year, XYZ has defaulted on its debt obligations and currently trades at 60% of par. Which of the following statements is true?
   A. The contingent payment from the protection buyer to the protection seller is greater under the single-name CDS than the digital swap.
   B. The contingent payment from the protection buyer to the protection seller is less under the single-name CDS than the digital swap.
   C. The contingent payment from the protection seller to the protection buyer is greater under the single-name CDS than the digital swap.
   D. The contingent payment from the protection seller to the protection buyer is less under the single-name CDS than the digital swap.

2. The Big Bank Corp has securitized a large pool of 100 mortgages as follows: $75 million in senior AAA notes, $20 million in mezzanine BB notes, and $5 million in equity tranche. Big Bank Corp would like to provide a credit enhancement to the issue. Which of the following strategies would most effectively reinforce the credit rating of the AAA notes?
   A. 26th-to-default basket.
   B. Standard basket.
   C. Senior basket with $25 million loss level.
   D. Subordinated basket with $25 million loss level.

3. Consider a basket with 10 AA-rated single-name credits, each with $10 million notional principal. Assume the pairwise correlation between each of the credits is zero. Which of the following statements about senior, subordinated, standard, and *n*th-to-default is most likely false?
   A. The senior basket will payoff the smallest amount to the protection buyer.
   B. The subordinated basket will provide more credit protection than the senior basket.
   C. The standard basket will provide the most credit protection.
   D. The payoff on the second default will be less than the payout from the first default.

4. Which of the following statements about credit-linked notes is true?
   A. The borrower receives an enhanced coupon.
   B. The borrower receives a reduced coupon.
   C. The lender receives an enhanced coupon.
   D. The lender receives a reduced coupon.

5. Which of the following statements about credit indices is true?
   A. The single name credits are value weighted by size of underlying reference.
   B. CDS indices are concentrated in European markets.
   C. Each CDS index has a finite life.
   D. CDS indices are mainly used as benchmarks and not tradable assets.

## Concept Checker Answers

1. **D** Choices A and B can be eliminated because payments in default are made from protection seller to protection buyer. The payoff from the digital swap will be 50% of par value while the payoff from the single name will be 40% (i.e., 1 – 0.6) of par value.

2. **C** The senior basket provides compensatory payouts after $25 million in loss is suffered by the pool. Because the goal is to enhance the AAA notes, $25 million can be absorbed by the mezzanine and equity investors without impairing the AAA notes. Assuming all credits are of equal size, the 26th-to-default basket would provide minimal protection since all defaults above 26 would directly impair AAA claims. The standard basket would provide protection starting with the first default and thus would be very expensive if used to protect the AAA notes.

3. **D** Statements A, B, and C are most likely true. Because the credits are uncorrelated, it is extremely unlikely that the loss level will exceed the threshold for a senior basket. Similarly, with relatively few expected defaults, the subordinated basket will provide more credit protection than the senior basket. The standard basket will pay each default without limit so this will provide the most credit protection. Statement D is false because the impairment, hence payout, for each default is expected to be the same because each credit covers the same notional principal.

4. **C** In a credit-linked note, the lender (note holder) receives an enhanced coupon as compensation for bearing the credit risk of the issuer.

5. **C** Each CDS index has finite life as a new issue rolls out every six months. After five or ten years, the index is retired. CDS indices use equal weighting, not value weighting. CDS indices are geographically dispersed with broad coverage of North America, Europe, and Asia. CDS indices are primarily used as traded assets, not as benchmarks.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# The Structuring Process

Topic 34

## Exam Focus

Structured finance is the process of designing securities that alter the risk profile and payoff of the underlying assets of the firm. Structuring products are often motivated by raising capital at an overall funding cost less than direct issuance. Ring-fencing legally separates the assets from the firm and can lead to lower financing costs. Structuring can be motivated by risk transfer, agency cost reduction, raising project specific capital, or meeting specific investor demands. For the exam, you need to know the role and participants in the structuring process including economic motivation, structuring agent, waterfall cash flow model, legal structure, and security design (maturity, tranching, ramp up). In terms of security design, subordination and tranching are critical to allocating more or less risk to each investor class.

## Structured Finance and Asset Securitization

### LO 34.1: Describe the objectives of structured finance and explain the motivations for asset securitization.

**Structured finance** is the process and creation of financial assets that are "non-standard." The typical structuring involves combining bonds with other derivatives or embedded options that alter the distribution of cash flows. The goal of structured finance is to allow the firm to alter its risk profile or to raise external capital at funding costs lower than its stand-alone current creditworthiness would dictate. Thus, structured products are customized financing solutions, and implementation differs from firm to firm.

Some common reasons cited for structuring are briefly summarized. First, the firm may want to issue secured debt by specifically pledging assets as collateral. In this way, the firm lowers its cost of capital and, in the event of liquidation, these assets are only available to satisfy the claims of secured creditors. Second, investors naturally face an information disadvantage and may find it hard to monitor the risk and performance of the underlying assets. Pledging high quality assets mitigates this asymmetry. Third, the assets themselves may be complex or hard-to-value instruments. By isolating these assets, the firm may increase the overall transparency of the firm and lower its overall cost of capital. Fourth, investor appetite for particular assets may allow the firm to sell these claims at more attractive rates, thereby lowering the overall weighted cost of capital.

In contrast to the above discussion, asset securitization involves selling the assets and the rights to their future cash flows. The net effect is that the firm has shed itself of the assets and received payment from the acquirer's contemporaneous issuance of claims against the same assets.

The motivations for securitizing assets are quite similar to the rationale for structuring secured assets. First, the seller may want to establish a "**true sale**" to obtain off balance-sheet financing. Thus, the assets must be "bankruptcy remote" from the seller (originator) to qualify for favorable accounting status. Note that simply by pledging the assets, they will remain on balance sheet, which is not sufficient for "true sale" status. Second, securitization allows for separation between the risk of the firm and risk of the assets. Third, securitization allows the firm to alter its balance sheet, removing debt and other liabilities. For financial institutions, this may also reduce the amount of regulatory capital required to be held on reserve. Finally, overall transparency of the originator will increase after selling the opaque assets, leaving behind the more transparent ones.

## Ring-Fencing Assets

### LO 34.2: Describe the process and benefits of ring-fencing assets.

**Ring-fencing** is when the firm separates specific assets (or even entire business units) into a distinct legal entity. The process is quite flexible as the firm may issue specific claims against the asset and/or maintain an equity interest in the new entity. Note that the ring-fenced assets are backed both by newly issued debt and the parent's equity stake in the new entity. Of course, the debt has a higher priority on the cash flows generated by the underlying assets.

There are several advantages to the firm from ring-fencing assets:

- *Risky assets*. Suppose the firm owns potential risky assets but does not want to outright sell the assets, thus losing the potential future benefits. The firm can instead ring-fence the assets in a bankruptcy-remote entity.
- *Improved creditworthiness*. If the firm places assets into its own legal entity, it may be able to issue debt at more favorable terms than if the parent issued the debt directly. In addition, it is easier for the firm to enhance (e.g., overcapitalize) the structure to ensure a higher credit rating.
- *Runoff.* When the firm is considering an exit strategy, it may be more manageable if the assets are housed in their own investment vehicle. This will improve transparency and valuation of the isolated assets.
- *Collateral*. The firm chooses to use the assets as collateral for newly issued debt as opposed to issuing secured debt. This is sensible for large-scale capital-intensive projects.
- *Tax/Legal*. The firm may be able to obtain more favorable tax or legal status.
- *Adverse selection.* High adverse selection costs such as information asymmetry or opaqueness of assets or investments makes monitoring costly. The increased transparency of isolating the assets allows outsiders to more easily place a higher value on the subject assets.

## Role of Structured Finance

**LO 34.3: Describe the role of structured finance in venture capital formation, risk transfer, agency cost reduction, and satisfaction of specific investor demands.**

The previous discussion on ring-fenced assets implicitly assumed the firm owned the assets. It is possible, however, that the firm needs to raise funds for a risky venture (i.e., purchase assets). Under these circumstances, the firm may wish to separate the assets and its associated risks and potential benefits into its own separate entity, such as a **special purpose entity** (SPE). This arrangement facilitates the valuation and raising capital process.

Ring-fencing assets may allow the firm to manage the inherent risk of its operations better than outside investors. In this case, it makes sense for the firm to structure its claims in a non-standard fashion. For example, consider a specialty bread manufacturer who clearly bears the risk of rising commodity input prices such as wheat. The manufacturer can choose to remain unhedged by issuing straight debt and, thus, passing on the commodity risk to investors. Investors recognize this risk and will discount the security appropriately for the cost of directly hedging themselves. Alternatively, the manufacturer can structure its debt so that, say, the coupons are indexed to wheat prices, thereby providing investors with a built-in hedge on input prices. If the firm can structure this note cheaper than the investors can self-hedge (which is likely), the firm has strong motivation for structured finance.

Corporate finance has long recognized that the various claimants of the firm have competing interests and associated agency costs. For example, the primary concern for both banks and bondholders is the repayment of principal and interest. Both have a natural preference for the borrower to select safer projects that increase the likelihood of repayment even if the long-run expected firm value is lower than expected firm value if riskier projects are selected. Shareholders, on the other hand, prefer the riskier projects since their claim is residual. Structured financing may mitigate these competing concerns, increasing the efficacy of project selection.

Finally, a firm may consider structured financing to satisfy investor demands that are not met elsewhere in the market. For example, the specific structuring of the debt claims may create a new risk-return profile that investors desire. Second, investors may only be willing to bear partial risk of the issuer. Consider an investor who may be willing to bear market risk because his investment horizon is long, or he has the means to hedge market risk but is unwilling to bear interest rate risk. Under these circumstances it may make sense for the issuer to structure the security to hedge interest rate risk, but not any of the remaining market risks. Third, the current legal structure of the firm may not allow for optimal risk tranching of asset cash flows. The structuring process can redesign the cash flow distribution to better match investor demand. Finally, creative structuring may provide access to previously unavailable investing opportunities due to external constraints. Consider a life insurance company that is precluded from investments in the biotech sector because of the large variation in expected returns. However, if the biotech company can divert the cash flows from products that have patent protection, and hence, high predictability, this now becomes an investable asset for the life insurance company.

## The Structuring Process

**LO 34.4: Explain the steps involved and the various participants in the structuring process.**

While the specifics of structuring will vary from issue to issue, we can highlight the general process. Note that the following steps may vary in sequence and importance depending on the motivation and complexity of the deal.

The first step in any structuring process is identifying the economic motivation. There must be a clear reason why a structured product is preferred to traditional, less costly financing. Care must be taken to confidently assess if the benefits of the additional complexity offset the higher costs of structuring, monitoring, and financing. A critical component is analyzing the cash flow waterfall structure. The resulting distribution will identify the expected cash flows and risks to the different investor classes. In addition, the waterfall should model anticipated expenses. At a high level, expenses can be divided into two mutually exclusive categories—senior and subordinated. **Senior expenses** are explicitly related to the structure, such as custodial and legal fees. These costs are independent of the performance of the asset pool and are considered fixed costs. On the other hand, **subordinated fees** are dependent on the performance of the asset pool (e.g., management fees). Since subordinated fees are derived from the residual waterfall cash flows, it is more important to explicitly model the senior fees.

A firm is unlikely to have the necessary expertise to structure and market their own issue, so it is necessary to employ a competent and experienced **structuring agent**. Clearly, the earlier the structurer is involved, particularly in identifying investor interest, the more streamlined and efficient the process will be. Further, the structuring agent may not be one-size-fits-all; that is, different agents will have different areas of expertise. The structuring agent may be the entity that suggests the offering or the entity that helps market and distribute the issue.

Another critical component of the structuring process is the proper design of the liabilities issued to investors. Important considerations include the maturity structure, tranching/subordination, and ramp up/execution phase. Clearly the maturity of the liabilities should be related to the cash flow properties of the asset pool. For example, it will be impossible to issue long maturity bonds to finance an infrastructure project against a collateral pool consisting of short-term accounts receivables. Tranching and subordination are absolutely critical decisions in separating the risk and return to different classes of investors. These concepts are the focus of the next LO. The structure must also specify the ramp up period, that is, the time frame to acquire, package, and sell the assets.

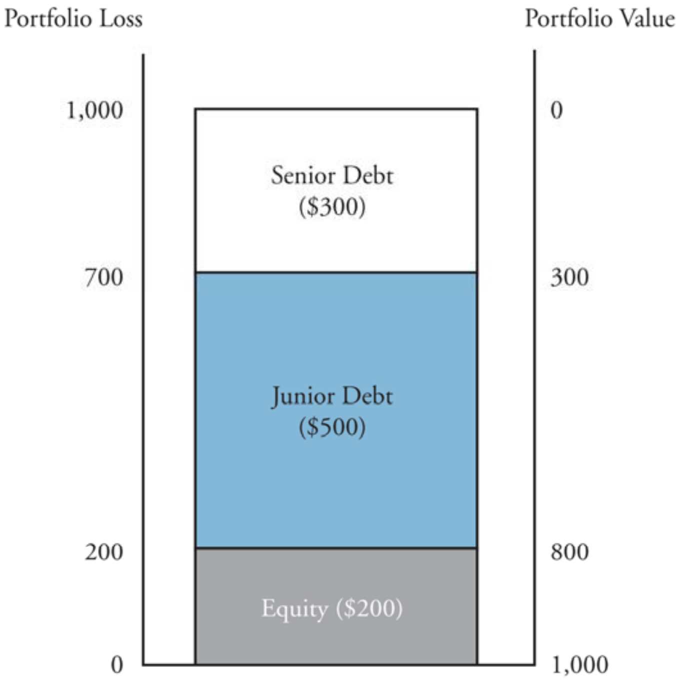
The final step is to design the legal vehicle that will ultimately house the assets. Clearly, this is a technical issue with many important tax, legal, accounting, and regulatory implications. While many variations exist, the structured finance solution will likely involve the creation of a new entity called a special purpose entity (SPE) or a special purpose vehicle (SPV), which was discussed in the previous LO. To provide some flavor of the potential complexity, consider that the SPE may be structured as a corporation or trust, more than one SPE may be necessary to achieve the specific objectives of the structured product, and the SPE may issue single or multiple series of securities.

## Tranching and Subordination

### LO 34.5: Describe the role of loss distributions and credit ratings in the structuring process.

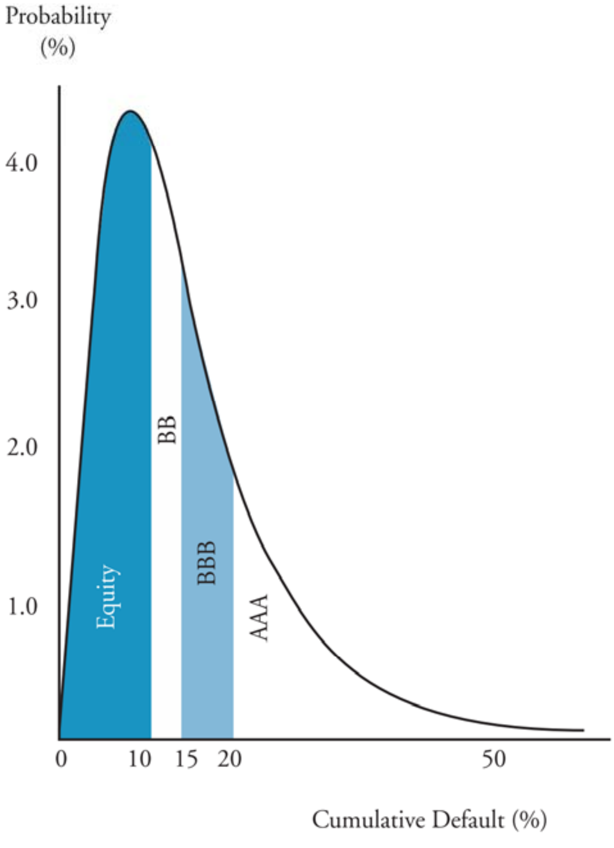
The process of **tranching** divides the claims against the assets' cash flows into a specific ordering or layering. Claims with the most seniority have implicit protection from the layer of investors below them, and so on. Structuring the claims in this fashion creates **subordination** at clearly defined break points or attachment points. For illustration purposes, let's suppose a simplified capital structure consisting of equity tranche ($200 million), mezzanine or junior tranche ($500 million), and senior debt tranche of ($300 million), that backs a $1 billion asset pool. This information is displayed in Figure 1. Thus, the most subordinated tranche (equity) provides credit protection (up to its loss level) for all tranches senior to itself. The second tranche (mezzanine) provides additional credit protection above and beyond the subordinated claims (up to its loss level) for all the more senior tranches. This process continues up to the most senior tranche, which must bear all the remaining credit risk. In terms of this example, the equity tranche will absorb the first $200 million of portfolio losses. If the loss level exceeds $200 million, then the mezzanine tranche will absorb the next $500 million in losses for a total cumulative subordination of $700 million. Finally, the senior debt will have to bear any losses exceeding $700 million.

**Figure 1: Illustration of Tranching**



It is immediately evident, based on this subordination scheme, that the probability of impairment is inversely related to the subordination level. Specifically, the lower (higher) subordinated tranches have the highest (lowest) probability of suffering impairment implied by the waterfall distribution of the cash flows. The process described above creates a loss distribution. The loss distribution can be visualized as a graph of cumulative defaults (relative to total assets) on the x-axis against cumulative probabilities of default on the y-axis. This is illustrated in Figure 2. The loss distribution can then be mapped against the implied credit ratings. In fact, this process is exactly what rating agencies will do in assigning credit ratings to the different tranches.

**Figure 2: Loss Distribution**



## Key Concepts

### LO 34.1

Structured finance allows the firm to alter its risk-return profile by redesigning the underlying cash flows of the firm or selected assets. This creates opportunities for the firm to lower its financing costs and/or provide access to investors that were previously unavailable.

### LO 34.2

Ring-fencing assets legally separate the assets from the rest of the firm. This process may be motivated by isolating a risky venture to protect existing assets, increasing transparency of assets, lowering borrowing cost relative to originator, facilitating an exit strategy, or achieving favorable tax/legal status.

### LO 34.3

Structured finance facilitates the raising of capital for new (risky) ventures, efficient risk transfer between the firm and investors, reducing agency costs by isolating assets, and satisfying specific investor demands.

### LO 34.4

The structuring process is complex and involves several generic steps. The order and importance of each step will depend on the specifics of the financing deal. The deal must clearly state the economic motivation, waterfall distribution of asset cash flows (including senior expenses), proper choice of structuring agent, and appropriate legal structure. The design of the actual securities is complex and must consider maturity matching, tranching/subordination, and ramp up period.

### LO 34.5

Subordination is the process of tranching the claims against the promised cash flows in such a way that lower rated tranches provide credit protection for all more senior tranches. A loss distribution is generated so that the more senior the tranche, the higher the assigned credit rating.

## Concept Checkers

1. All of the following are valid reasons for a firm to ring-fence assets, except to:
   A. reduce information asymmetry.
   B. maintain legal control over the ring-fenced assets.
   C. obtain favorable tax or legal status.
   D. increase the transparency of asset cash flows.

2. Asset securitizations are most likely motivated by which of the following reasons?
   A. To create off-shore tax havens.
   B. To separate the risk of the structuring agent from the risk of the assets.
   C. To increase the transparency of the issuer.
   D. To increase the subordination levels.

3. Which of the following statements about preliminary cash flow waterfalls is true?
   A. Cash flows should be modeled based on revenues and subordinated expenses.
   B. Cash flows should be modeled based on liabilities and subordinated expenses.
   C. Cash flows should be modeled based on revenues and senior expenses.
   D. Cash flows should be modeled based on revenues only.

4. Big Pharmaceutical (BP) has begun research on a potentially profitable but controversial prescription drug. It is concerned about possible negative side effects and does not want any financial liability to accrue back to Big Pharmaceutical. As the structuring agent in preliminary talks with BP, what is your recommendation?
   A. Issue secured debt so that investors can see the assets used to back the project.
   B. Issue unsecured debt since the company is large and profitable.
   C. Ring-fence the assets for favorable tax treatment.
   D. Securitize the assets into an SPV.

5. Suppose the structuring agent for Big Pharmaceutical has suggested the following capital structure for the structured solution. The $600M project will be tranched into $100 senior fixed debt, $200 junior floating debt, and $300 floating equity tranche. The anticipated respective ratings on the tranches are AAA, AA, BBB. As the CFO of BP, you have some questions about the subordination levels. Which of the following is most likely your biggest concern?
   A. The equity tranche is too small.
   B. The senior tranche is too large.
   C. The credit rating on the equity tranche is too high.
   D. The junior tranche should have a higher cumulative loss level.

## Concept Checker Answers

1. **B** Statements A, C, and D are advantages of ring-fencing assets. Although the parent may maintain an equity stake that is possibly significant, that is not the primary objective of ring-fencing.

2. **C** Securitizing assets will increase the transparency of the originator. Choices A and D are incorrect statements. For choice B, asset securitizations separate the risk of the firm from its assets, not the structuring agent.

3. **C** Waterfall models should ideally include revenue forecasts, liabilities, and both senior and subordinated expenses. However, in preliminary models, only senior expenses are included. Only choice C contains correct elements.

4. **D** The best choice for BP would be to remove the assets from the balance sheet into a legally separate entity (SPV).

5. **C** In a standard subordination, the equity tranche will be quite small (5% or less) and is very risky as it absorbs the first losses. Hence, its credit rating will be very low or not rated at all. Clearly, 50% equity [300 / (100 + 200 + 300)] is too large. Therefore, statements A and B are backward—you would prefer a small equity tranche and large senior debt to lower overall cost of funds. The junior tranche should actually be smaller with a lower credit rating (say B range). This would allow the senior tranche to be larger and still maintain the AAA rating. Note that we cannot specify how much larger or the exact attachment point without the loss distribution.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Securitization

Topic 35

## Exam Focus

Securitization is the process of selling cash-flow producing assets to a third party (special purpose entity), which in turn issues securities backed by the pooled assets. Securitizations are often structured with internal (e.g., overcollateralization) or external (e.g., letters of credit) enhancements. Mortgage-backed securities securitize residential mortgages where the property serves as the collateral. For the exam, be able to describe the securitization process and be able to identify the various internal and external credit enhancements discussed.

### LO 35.1: Define securitization, describe the securitization process and explain the role of participants in the process.

**Securitization** is the process of selling credit-sensitive assets (i.e., debt obligations) to a third party that subsequently issues securities backed by the pooled cash flows (principal and interest) of the same underlying assets. Cash is transferred to the selling party, and the obligation is effectively removed from the seller's balance sheet if the sale is made without recourse (i.e., a true sale). Hence, securitization represents an off-balance-sheet transaction. Further, there exists a wide range of assets that can be securitized (e.g., mortgages, credit card receivables, auto loans), but the common feature is that the underlying assets generate cash flows. In the process just described, it is important to note that the third party was not involved in the original transaction.

## Participants in the Securitization Market

The following is a comprehensive list of participants in a typical securitization. However, all parties need not be involved to complete a securitization.

- **Originator/Transferor.** The originator is the entity that seeks to convert its credit-sensitive assets into cash ("monetize" the asset). The credit risk is then transferred away from the originator.
- **Sponsor.** The sponsor is the initiator of the securitization. If a bank wants to securitize its own loans, the bank is both the sponsor and originator. For a non-financial company, the company may initiate the process to monetize its accounts receivable (serve as own sponsor), or an outside financial institution may initiate the securitization (external sponsor).

- **Asset purchaser/Transferee/Securitized product issuer.** This refers to the third party who stands between the originator and the eventual purchaser of the securities. As the name implies, the asset purchaser literally buys the assets from the originator. The transferee is a distinct legal entity from the originator. When the structure is created solely for the purpose of buying the assets, it is called a **special purpose entity** (SPE). The SPE may be a company or trust (more on this in the next LO). Freddie Mac and Fannie Mae are transferees in the mortgage market.
- **Trustee.** The trustee is charged with the fiduciary responsibility to safeguard the interests of the investors who purchase the securitized products. The trustee will monitor the assets based on prespecified conditions of the asset pool such as minimum credit quality and delinquency rates.
- **Custodian.** Historically, the custodial role was to safeguard the physical securities, but has evolved to also collect and distribute the cash flows of assets like equities and bonds.
- **Servicer.** The roles of the servicer and custodian have blurred in recent years and they may, in fact, be the same party. The servicer will collect and distribute the cash flows from the asset pool. The originator may retain the servicing rights, which can be valuable.
- **Structuring agent.** The structuring agent is the *de facto* advisor for the securitization issue. The agent will be largely, if not entirely, responsible for the security design (e.g., maturity, desired credit rating, credit enhancement) and forecasting the interest and principal cash flows. The structuring agent may also be the sponsor as the two roles have natural overlap.
- **Underwriter.** The underwriter is responsible for marketing and distributing the issue.
- **Rating agency.** While there is no explicit requirement for a credit rating, most issues, particularly the high-grade tranches, will be rated by Standard & Poor's, Moody's, and/or Fitch. Ratings can be assigned for both the issuer and the particular issue.
- **Law firm.** Legal counsel provides invaluable advice on structuring the assets (to be legally distinct from the originator), jurisdictional issues, proper accounting and regulatory compliance, and the like.
- **Regulatory agency.** Depending on the assets securitized and originator (e.g., bank), regulators may become involved.
- **External Risk Transfer and Risk Finance Counterparties.** The securitization process itself can generate new risks. If external risk transfer is deemed necessary, then additional counterparties may become involved in the securitization process.

## Issuing Securitized Products

### LO 35.2: Analyze the differences in the mechanics of issuing securitized products using a trust versus a special purpose entity.

The primary purpose of the transferee is to facilitate the securitization transaction. In the mortgage markets, Fannie Mae and Freddie Mac are pre-existing companies that are active asset purchasers. For most transactions, however, an entirely new legal entity called a **special purpose vehicle** (SPV) or **special purpose entity** (SPE) is constructed. The SPE may be designated as a corporation or a trust.

If the SPE is set up as a corporation, the originator sells the assets to the SPE in exchange for cash. The SPE in turn issues claims directly against the assets of the SPE. This method may not distance the originator from the assets enough for accounting purposes.

Under a trust arrangement, two distinct SPEs are created. The additional entity is created to further distance the originator from the issuer and the underlying assets. A common arrangement will involve a **master trust**, or **special purpose company** (SPC), and a **grantor trust**. In contrast to the previous approach (i.e., corporation), the assets do not serve directly as collateral. Under this arrangement, the originator sells the assets to the master trust (SPE 1) for cash, but the master trust in turn deposits the assets in the grantor trust (SPE 2). The master trust receives a beneficial interest in the grantor trust, which represents the same economic position as if only one SPE was employed. Now the claims of the securitized products are backed by the beneficial claim on the master trust rather than on the assets themselves.

If all of this seems needlessly complex, rest assured there is a good reason for it. The additional SPE sufficiently separates the originator from the issue so the assets can truly be considered "off balance sheet."

## Credit Enhancements

### LO 35.3: Describe and assess the various types of internal and external credit enhancements.

Distribution of credit risk is fundamental to structuring a securitized issue. For example, subordinated classes of securities will bear a disproportionate share of the credit risk. However, the wide variety of assets securitized, particular risk tolerances of investors, desired credit ratings, and other factors also create the need for other methods to allocate credit risk.

**Internal credit enhancement** is additional protection provided internally to the securitization structure. The most common internal enhancement is **overcollateralization** (O/C), when more assets are pledged to back the structure and exceed the liabilities. Imagine a mortgage pool that was securitized based on 100 mortgages, but the originator included 101 mortgages. The issue is overcollateralized by one mortgage (i.e., the investor can absorb one default before suffering any economic losses).

Let's look at an example to illustrate how overcollateralization enhances the creditworthiness of an ABS. Consider the following ABS structure:

- Senior tranche = $300,000,000.
- Subordinated tranche A = $80,000,000.
- Subordinated tranche B = $30,000,000.
- Total = $410,000,000.

The collateral value for the structure is $450,000,000, and Tranche B is first to absorb losses (the first loss tranche). The amount of overcollateralization for this structure is the difference between the value of the collateral and the combined value of all the tranches. That is:

overcollateralization = $450,000,000 – $410,000,000 = $40,000,000

This means that losses up to $40 million will be absorbed by the overcollateralization, and none of the tranches will experience a loss. Losses between $40 million and $70 million will be absorbed by Tranche B. Losses between $70 million and $150 million will be absorbed by Tranche A. Losses greater than $150 million will be absorbed by the senior tranche.

Several other internal credit enhancements are discussed as follows:

- **Direct equity issue.** The SPE issues debt with a face value less than the collateral in the pool. The difference could be made up by issuing equity; however, the demand for such slices of the asset pool is small. The originator may wish to retain a small portion of the equity, but this equity may violate the independence needed for transference to the SPE.
- **Holdback.** If the SPE pays fair value for the assets in the pool, there is no overcollateralization. However, if the SPE pays less than fair value for the assets, there is effective overcollateralization.
- **Cash collateral account** (CCA). The cash collateral account is reserves, not unlike an escrow account, set aside by the originator to cover losses in the pool. Of course, if there are no losses in the pool, the originator would want its reserves returned. However, the CCA runs into a similar problem as the direct equity issue method in that the originator is tied to the performance of the assets it sold and the transaction may not qualify as a true sale.
- **Excess spread.** An alternative method to O/C is to generate a positive excess spread between the collateral assets and the liabilities (coupons) of the SPE, less fees and expenses. The process is similar to a depository institution funding loans with lower cost deposits. The excess spread can accumulate in a CCA and can even accrue to equity holders after the SPE debt matures.

**Example: Computing excess spread**

Suppose that the interest earned on the collateral assets is 7.5%, and interest paid on the liabilities of the SPE is 6.25%. With fees and expenses totaling 0.4%, **calculate** the gross and net excess spread.

**Answer:**

The gross excess spread is the difference between the collateral asset and liability coupon rates.

$$\text{gross excess spread} = 7.5\% - 6.25\% = 1.25\%$$

The net excess spread is the difference between the gross excess spread and fees and expenses.

$$\text{net excess spread} = 1.25\% - 0.4\% = 0.85\%$$

**External credit enhancement** involves explicit credit risk transfer to an outside party. Examples include insurance and guaranties, letters of credit, credit default swaps, and put options.

- **Insurance, wraps, and guaranties.** The SPE effectively purchases protection for the senior bondholders with an insurance policy (guaranty) where the deductible is the amount allocated to the subordinated investors. In this case, any losses that affect the senior holders can be recovered via the insurance policy.
- **Letters of credit** (LOC). The SPE obtains a letter of credit for the senior dollar amount. If losses surpass the subordinated threshold, the credit line is drawn down to a maximum of the full senior debt level.
- **Credit default swaps.** Structuring a credit default swap on the full portfolio with a deductible set at the subordinated debt level will accomplish the necessary credit enhancement.
- **Put options on assets.** The put option allows the SPE to sell the collateral assets to the put writer for a predetermined price. If the put strike is set at the loss level of the subordinated tranche, then losses that would accrue to the senior holders (i.e., larger than the junior claims) are offset by the gains on the put position.

## Liquidity Risk in a Securitized Structure

### LO 35.4: Explain the impact of liquidity, interest rate and currency risk on a securitized structure, and identify securities that hedge these exposures.

Liquidity risk is the risk that the cash flows from the underlying assets are insufficient to meet the promises of the securitized product. This may stem from timing differences between the assets and liabilities or from cash flow shortages. An example of the former would be semiannual coupon-paying notes securitized to fund quarterly floating notes. The latter may result if the trade receivable collateral experiences higher than expected delinquencies so that the pooled cash flow may be insufficient to meet the fixed rate bonds issued against them.

Similar to credit enhancement, internal and external structures can be used to provide liquidity support for the issue. Two common *internal support mechanisms* are based on maturity structure and reserves.

**Maturity structuring** is analogous to managing credit risk via subordination. If the maturity of the liabilities is matched with the cash inflows from the collateral pool, the timing issue is resolved. However, this approach is too simple because late payments can unravel the cash flow matching even though there is no default per se. One solution is to issue an extendable note, a note with an intermediate and final maturity date. At the interim date, if the principal and interest waterfall structure is sufficiently strong, the note can be redeemed. Otherwise the security continues to final maturity.

*Professor's Note: Recall that in a principal waterfall structure, the most senior tranche receives its proportion of principal before any other class. Only after the senior tranche is paid off does principal waterfall to the next most senior tranche, and so on.*

**Liquidity reserves** are similar to the CCA discussed previously. Cash is set aside for the sole purpose of smoothing liquidity problems that may arise. In particular, the funds are used to guarantee that the liquidity ratios can conform to the designated credit rating. The reserve may be created by funding at the initiation of the asset-backed security (ABS) or may accumulate from the excess spread earned on the structure.

*External liquidity support* is obtained from outside the structure via letters of credit with recourse or asset swaps. An important distinction between credit support and liquidity support is that liquidity support does not guarantee performance and is not responsible for making up shortfalls.

**Letters of credit with recourse** allow the SPE to drawdown a line of credit to continue to make its promised payments to investors. However, the originator, not the SPE, is liable to repay the principal and interest from all draws on the credit line. Recent regulation has reduced the use of recourse LOCs for several reasons. First, the new Basel Accord requires capital to be held against short-term LOCs, which was not required under the original Basel. Second, conditioning the payment of the originator based on the performance of the SPE questions the independence between the originator and the SPE.

**Asset swaps** are derivative securities that swap fixed payments for floating payments where the fixed payments are based on a reference asset. The floating side pays a fixed amount (asset swap rate) over LIBOR. Asset swaps are useful for converting fixed rate assets into floating rate assets.

The key to the use of asset swaps for liquidity support is based on the timing flexibility of the asset swap. The SPE pays the principal and interest to the swap dealer as the cash flows are received. The dealer sends the floating rate payment to coincide with the floating obligations of the SPE. The swap dealer would provide credit protection in the event of one or more defaults (the asset swap is now a total return swap). To adjust for providing liquidity support only, the notional principal is adjusted downward for defaults.

## Interest Rate Risk and Currency Risk

Interest rate risk can arise from either structural differences or maturity differences between the underlying collateral and the obligations of the securitized structure. First, let us consider the impact of structural differences. Suppose a floating-rate liability is issued against a pool of fixed rate assets. Therefore, an increase in the reference rate will narrow the spread between the fixed rate of the assets and floating-rate of the liability. If the interest rate rises sufficiently higher, it is possible that the floating-rate liability will exceed the cash flow provided by the collateral in any particular period.

Interest rate risk can also result when the collateral and ABS have different maturities or effective lives. Changes in the underlying interest rate can narrow the effective spread.

Currency risk is the risk resulting from a currency mismatch between the assets and liabilities of the securitized structure.

The same risk management tools that are available to hedge interest rate and currency risk for traditional fixed income products and portfolios are available for securitized assets, including swaps, futures, and forward rate agreements.

## Mortgage-Backed Securities and Asset-Backed Commercial Paper

### LO 35.5: Describe the securitization process for mortgage backed securities and asset backed commercial paper.

**Mortgage-backed securities** (MBS) are securitized assets backed by a pool of residential mortgages. However, the securitization process for residential mortgages is a little different than for other assets. First, the bank issues a mortgage to the homeowner who pledges the home as collateral on the loan. Hence, the collateral is not placed in the care of the trustee. Second, the homeowner purchases insurance to cover potential losses the bank may suffer. Third, the three government sponsored entities (GSE), Fannie Mae, Ginnie Mae, and Freddie Mac, are large purchasers of mortgages who then issue bonds backed by the principal and interest of the underlying mortgages. The GSEs serve as credit enhancers so there is virtually no default risk in the issue. However, MBS are not riskless because they are very sensitive to changes in prepayments and interest rates (i.e., the timing of the cash flows received).

MBS exhibit considerable variety in the cash flow distribution promised through the securitization. For example, the pooled cash flows may be distributed on a pro-rata basis or by tranching the cash flows (e.g., principal only and interest only strips). A common MBS structure is a collateralized mortgage obligation (CMO) whereby different classes of securities have different seniority. While all classes of the CMO receive periodic interest, principal payments are disbursed based on the waterfall distribution.

**Asset-backed commercial paper** (ABCP) follows the same basic securitization process. Trade receivables from one or more companies are pooled together, and short-term commercial paper is issued to investors. In contrast to other ABS, ABCP does not trade in an active secondary market. Hence, the typical investor has a short investment horizon since they hold the security to maturity. Another key difference is that ABS have a single conveyance of assets; once the liabilities are paid off, the structure terminates. ABCP, on the other hand, continually purchases new assets and offers new issues. Receivables typically do not have a stated maturity or bear interest, so there exists significant liquidity risk because of the fixed obligations of the commercial paper.

## Key Concepts

### LO 35.1

Securitization is the process of issuing securities against an asset pool. The proceeds of the security sale collateralize the purchase of the assets from the originator, thereby removing the liability and involvement of the originator.

The securitization process involves some, if not all, of the following: originator (transferor), sponsor, asset purchaser (transferee), trustee, custodian, servicer, structuring agent, underwriter, rating agency, law firms, regulatory agencies, and risk finance counterparties.

### LO 35.2

The securitization process may use either a corporation or trust as the SPE.

Claims are issued against the master trust, effectively separating the assets from the originator.

### LO 35.3

Subordination and overcollaterlization are common internal credit enhancements. Insurance, letters of credit, credit default swaps, and put options are external credit enhancements.

### LO 35.4

Liquidity risk is the risk that the cash flows from the underlying assets are insufficient to meet the promises of the ABS.

Internal liquidity enhancement can be based on maturity structuring or reserve funding. External liquidity enhancements utilize full recourse lines of credit or asset swaps.

Interest rate risk may result from timing differences between assets and liabilities or from structural differences. Currency risk is the risk resulting from a currency mismatch between the assets and liabilities of the securitized structure.

### LO 35.5

Mortgage-backed securities are securitized assets where residential mortgages serve as the underlying collateral.

ABCP is short-term commercial paper backed by a pool of receivables. The asset-liability mismatch creates significant liquidity risk.

## Concept Checkers

1. A transaction in which the originator transfers a pool of loans to a special purpose entity and has no remaining liability is a:
   A. true purchase.
   B. true sale.
   C. subordinate transfer.
   D. partial transfer.

2. Five tranches of auto loan asset-backed securities are issued with a face value of \$6,000,000 and pay an average coupon of 5.2%. The value of the auto loans is \$6,800,000, and they have an average interest rate of 5.4%. The fee for servicing the ABS is 0.2%. Which of the following are credit supports involved with this transaction?
   A. Excess spread.
   B. Cash reserve account.
   C. Direct equity issue.
   D. Overcollateralization.

3. Which of the following types of risk is not a potential risk associated with securitizing credit-sensitive assets?
   A. Liquidity risk.
   B. Interest rate risk.
   C. Currency risk.
   D. Maturity risk.

4. What is the first step in the securitization process for residential mortgages?
   A. The homeowner purchases insurance to cover potential losses the bank may suffer.
   B. Government sponsored entities issue bonds backed by principal and interest.
   C. The bank uses the reinsurance market to help homeowners insure the new property.
   D. The bank issues a mortgage to the homeowner who pledges the home as collateral on the loan.

5. How many of the following individuals/entities can be participants in the securitization market?

   I. Sponsor.
   II. Trustee.
   III. Rating agency.
   IV. Structuring agent.
   V. Law firm.

   A. One.
   B. Three.
   C. Four.
   D. Five.

## Concept Checker Answers

1. **B** A "true sale," or absolute transfer, of the assets must take place in order for any potential benefits from risk transfer to occur.

2. **D** The ABS is supported by overcollateralization since the value of the asset pool is greater than the value of the securities. There is no excess spread involved since the interest from the asset pool is equal to the weighted coupon on the ABS plus servicing fees. Neither cash reserve account nor direct equity issue are mentioned in the question.

3. **D** Maturity risk is not a risk directly associated with a securitization structure. Liquidity risk is the risk that the timing of the cash flows from the collateral will be unable to satisfy the issued claims (e.g., collateral with semiannual payments that is funding monthly coupon-paying bonds). Interest rate risk can occur from a maturity differential between assets and liabilities as well as structural differences (e.g., fixed-rate assets funding floating rate liabilities). Currency risk can arise if the collateral and issued claims are in different currencies.

4. **D** The first step in the securitization process for residential mortgages is the bank issues a mortgage to the homeowner who then pledges the home as collateral on the loan.

5. **D** The following is a partial list of participants in a securitization: sponsor, trustee, rating agency, structuring agent, and law firm.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Cash Collateralized Debt Obligations

Topic 36

## Exam Focus

This topic discusses the different types, motivations, and structures of various cash collateralized debt obligations (CDOs). CDOs are generic structures where investors are promised principal and interest backed by a pool of debt instruments (bonds, loans, or both). The motivation may be either credit management (balance sheet CDO) or investment management (arbitrage CDO). Market value CDOs differ from cash flow CDOs by selling assets from the collateral pool to satisfy investor obligations. Some CDOs are static (passive investments) while others are actively managed (light or full-blown active management). For the exam, be able to compare and contrast balance sheet and arbitrage CDOs.

## Collateralized Debt Obligations

### LO 36.1: Describe collateralized debt obligations (CDOs) and explain the motivations of CDO buyers and sellers.

### LO 36.2: Describe the types of collateral used in CDOs.

Collateralized debt obligation is the general term for an asset-backed security that issues securities that pay principal and interest from a collateral pool of debt instruments. The generic name CDO implies that the underlying collateral is comprised of a collection of debt and loans.

A convenient way to describe CDOs is by the underlying collateral or economic purpose (e.g., balance sheet CDO or arbitrage CDO). If the underlying collateral pool consists entirely of bonds, the issue is referred to as a **collateralized bond obligation** (CBO), and if the underlying collateral pool consists entirely of loans, the issue is referred to as a **collateralized loan obligation** (CLO).

In order to create a CDO, the issuer packages a series of debt instruments and splits the package into several classes of securities called **tranches**. Each tranche has a different claim on the collateral pool's cash flows and different exposures to the default risk of assets in the pool. The largest part of a CDO is typically the senior tranche, which usually carries a AA or AAA credit rating, regardless of the quality of the underlying assets in the pool. The senior tranche is accompanied by a series of mezzanine tranches and an equity tranche. The equity tranche is commonly referred to as the first loss tranche because it is the first to absorb any losses from the debt securities in the pool, making it the riskiest part of the CDO structure. Subsequent losses are absorbed by the mezzanine tranches, making the senior tranche the last in line to have any loss exposure.

The first CDO was issued in the late 1980s, with a value of $100 million. Today, CDO issuance is estimated to exceed $150 billion. The key to the growth of the CDO market is that CDOs give investors, banks, and brokerage firms the ability to repackage and transfer credit risk. Specifically, the growth of the CDO market can be explained by four factors:

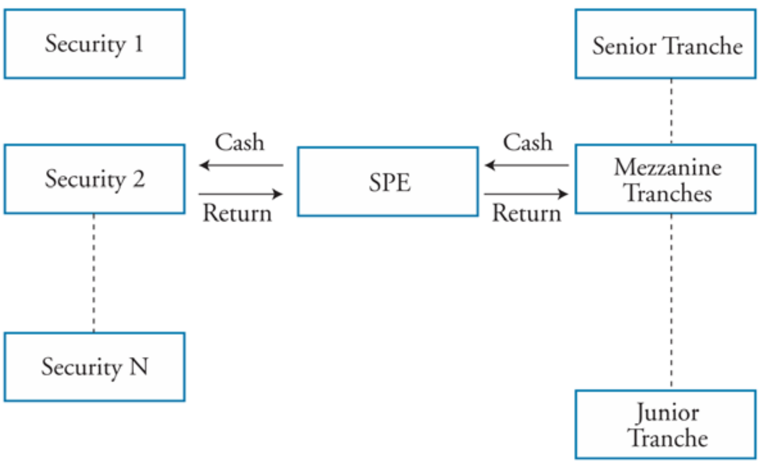
1. *CDOs give investors access to a diversified pool of risky credit assets.* Risky credit assets have a low correlation with the S&P 500 and the U.S. Treasury bond market. As a result, these assets provide excellent potential for diversifying a traditional stock and bond portfolio. The use of CDOs gives investors an efficient way to gain exposure to various classes of risky credit assets.

2. *Credit tranching allows investors to select specific credit risk exposures.* CDOs issue multiple tranches of securities against each collateral pool, with each having a different seniority and credit exposure. Tranching allows investors to pinpoint a specific credit risk exposure within a given class of security.

3. *CDOs give banks an effective way to manage credit risk.* Banks can use CDOs to transfer risky credit assets off their balance sheets, thus freeing up regulatory capital and reducing risk exposure.

4. *Fees are collected by asset managers and underwriters.* Asset managers collect asset management fees for managing the CDO structure, while brokerage firms collect underwriting fees for selling CDO tranches to clients. The combination of investor demand and profits for supplying CDOs is a powerful incentive for continued growth in the CDO market.

**Figure 1: A Cash CDO With *N* Underlying Securities**



## Balance Sheet vs. Arbitrage CDOs

**LO 36.3: Explain the structure and benefits of balance sheet CDOs and arbitrage CDOs, and the motivations for using them.**

The **balance sheet CDO** is motivated by the asset owner wishing to remove the selected assets from his balance sheet. Potential motivations include credit risk management, liquidity, raising capital, and debt management. Consider a bank that sells part of its loan portfolio, thereby replacing longer duration assets (loans) with shorter duration assets (cash).

On the other hand, investors constantly demand new and innovative securities with enhanced yield and specific risk-return profiles that fit their investment criteria. This demand gave rise to the **arbitrage CDO**. Specifically, arbitrage CDOs are financially engineered products designed to profit on the spread between the assets in the pool and the promised payments to security holders.

The clear differences in motivations between balance sheet CDOs and arbitrage CDOs lead to important distinctions in the management and structure of the asset pool. The arbitrage CDO implies active management and employs a separate collateral manager. The balance sheet CDO is much simpler—the originator selects the assets for conveyance and remains "hands off." The originator may seek the help of the structuring agent or advisor, but the role is much more limited than the collateral manager of the arbitrage CDO.

The fundamental nature of the balance sheet CDO dictates the asset structure. Because the originator is very likely to be a bank, the targeted assets are typically loans. Therefore, the specific pool will be considered a CLO. While the size and composition will of course vary from pool to pool, the CDO will contain assets in excess of $1 billion formed from many loans or syndicated loan participations.

Under this structure, it is natural for the investors to have concerns about the quality and performance of the pool. To provide assurances to the investor beyond subordination, the originator may include credit enhancements such as a **cash collateral account** (CCA). The cash collateral account accumulates a portion of the excess spread, typically 50bps, to fund potential shortfalls in promised payments. The originator will also retain the residual interest (i.e., first-loss piece of the loss distribution), reducing the worry that the loans selected for inclusion are sub-standard.

The driving force behind the arbitrage CDO is financial engineering of the collateral cash flows which leads to a very different structure than the balance sheet CDO. First, the collateral manager will acquire the underlying assets from the open market (as opposed to the originator's balance sheet). Hence, the structure is more likely to be weighted with bonds. The role of the collateral manager is to actively purchase, reinvest, divest, and hedge the cash flows of the pool.

Once the assets are purchased, they will be sold to the special purpose entity (SPE) for cash, which ultimately comes from the investors. The assets are held in trust for the investors and backed by the securities (and credit enhancements) issued by the SPE. Another distinction between balance sheet and arbitrage CDOs is the residual interest. The balance sheet

CDO engenders a moral hazard problem by self-selecting the assets for the collateral pool. Therefore, the originator will include features like the CCA and retain the residual interest. In contrast, the residual interest in the arbitrage CDO may be sold to investors. The primary differences between balance sheet CDOs and arbitrage CDOs are summarized in Figure 2.

**Figure 2: Balance Sheet CDO vs. Arbitrage CDO**

| | *Balance Sheet CDO* | *Arbitrage CDO* |
|---|---|---|
| Typical underlying assets | Loans | Bonds |
| Asset origination | Originator balance sheet | Open market |
| Management | Passive | Active |
| Purpose | Credit risk management | Profit |
| Residual interest | Retained by originator | May be sold to investors |

As mentioned earlier, the motivations for balance sheet CDOs and arbitrage CDOs are quite different. It was noted that the balance sheet CDO is essentially a sale of self-selected assets. Hence, the firm may seek to monetize the assets for cash, maintain debt capacity, or reduce the size of the balance sheet. Other reasons include isolating the assets to reduce the adverse selection costs of self-selected "lemons" and increasing transparency, which, in turn, should lower the firm's weighted average cost of capital. Similarly, the firm can experience a slight benefit by reducing the assets under management control and avoiding poor, value-decreasing investments. Finally, credit risk management via balance sheet CDOs has the potential to free up capital under Basel II regulations.

The motivation and benefit of arbitrage CDOs overlap substantially with balance sheet CDOs. These issues are constructed with the sole purpose of providing new investment opportunities by altering cash flows to create new investment vehicles. The collateral manager simultaneously seeks to maximize the funding gap between the collateral pool and the weighted average cash flows due to investors.

## Cash Flow vs. Market Value Arbitrage CDOs

### LO 36.4: Compare cash flow and market value CDOs.

The primary difference between **cash flow arbitrage CDOs** and **market value arbitrage CDOs** depends on the source of the cash used to satisfy investor claims. Cash flow CDOs satisfy the principal and interest obligations to investors from the associated cash flows (i.e., scheduled principal and interest) on the collateral pool. On the other hand, market value CDOs would periodically sell securities from the collateral pool to manage the promised investor claims. Market value CDOs are rapidly disappearing from this segment of the market.

## Static vs. Managed CDOs

### LO 36.5: Compare static and managed portfolios of CDOs.

**Static CDOs** essentially describe balance sheet CDOs. The collateral assets are purchased, placed in the collateral pool, and distributed based on the cash flows of the underlying assets. No active management is needed and the structure basically runs itself until termination.

**Managed CDOs** involve varying degrees of active management. If the CDO is lightly managed, the collateral manager will selectively (and preemptively) sell assets. In contrast, a static CDO collateral manager cannot sell assets even in anticipation of an adverse credit event. Finally, actively managed CDOs involve full-blown asset management. The collateral manager has the authority to sell, purchase, and manage the pool to maximize investor returns.

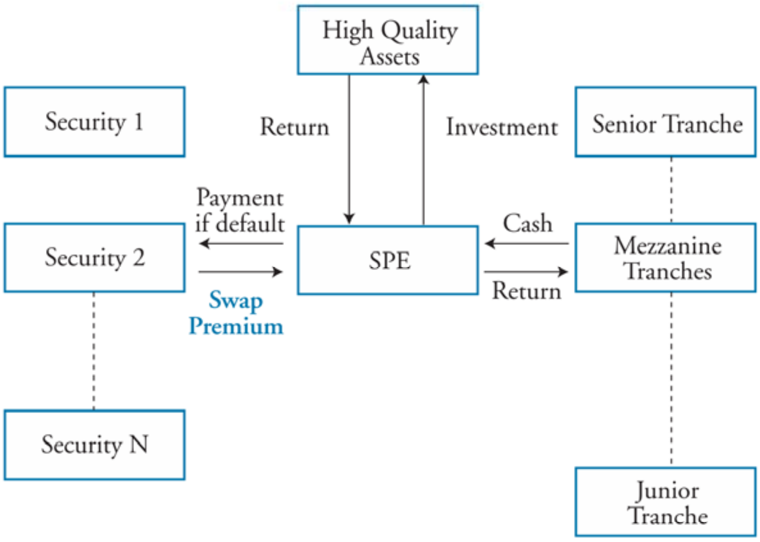
Both static and actively managed CDOs have a ramp-up period where the collateral manager selects and assembles the assets. Naturally, the larger and more complex portfolios will require longer ramp-up periods. After asset selection, the active manager must make reinvestment decisions. Typically, the manager will purchase new assets for the pool rather than pay down current note holders.

Finally, the degree of active management may affect legal and accounting aspects of the CDO. Additionally, the capital structure of arbitrage CDOs becomes more complex because of the performance-based management fees. The fees may be subordinated claims or partial interest in the residual equity tranche.

## Synthetic CDO

Under the cash CDO, the originator or collateral manager sells assets to the special purpose entity (SPE) for cash. A **synthetic CDO** (SCDO) creates the same economic exposure (i.e., risk and return) as the cash CDO but without a legal sale of assets. Rather, the credit exposure arises from the selling of credit protection (i.e., selling credit default swaps). The premium from the default swap and the funds from the sale of the tranches are used to buy high quality assets.

**Figure 3: Synthetic CDO With *N* Underlying Securities**




The benefit to the SPE is that, in a synthetic CDO, the assets are not legally transferred so they do not appear on the balance sheet. The SPE also does not have operational risk with respect to the original assets. In a cash CDO, it may be infeasible for political or legal reasons for the SPE to press for payment from the security issuer.

The synthetic CDO will be liable for the economic loss on defaults within the collateral pool from its obligations as a protection seller. At this stage, we note an important difference between the traditional CDO structure and the SCDO. Under the former, the CDO is prefunded as the actual assets are transferred to the pool. For the latter structure, the investor faces potential credit risk if the funds to cover defaults are still housed with the originator.

## Fully and Partially Funded Synthetic CDOs

When the securities are issued to investors and the funds collected are sufficient to cover all future defaults in the portfolio, they are considered fully funded. We have previously discussed one fully funded security already—the credit-linked note (Topic 36). Recall the investor in this structure is also the protection seller and receives the enhanced coupon. But, in case of default, the protection seller (investor) has already deposited the par value of the security and maintains the long position on the actual note. This effectively describes physical settlement of a CDS.

For a synthetic CDO, fully funded signifies that the cash raised from investors is enough to cover the maximum payout on all of the credit protection sold via SCDO. As was the case for the cash CDOs, the structural differences between balance sheet and arbitrage CDOs carry over to their synthetic counterparts. We briefly discuss each in turn.

For the fully funded **balance sheet SCDO**, a reference portfolio is identified by the originator. Notes will be issued by the SPE for the exact size of the reference portfolio. The proceeds from the sale are held by the trustee who purchases high quality assets. In turn, these securities are then pledged as collateral to the originator to back the credit protection sold.

Just as the arbitrage CDO had important differences with the balance sheet CDO, the same holds for their synthetic counterparts. The **arbitrage SCDO** uses the collateral manager to select the reference collateral pool. The SPE creates the credit exposure by selling the CDSs, which effectively synthetically securitizes the collateral pool. As with arbitrage CDOs, the collateral manager may lightly or actively manage the pool, thereby adding, selling, or hedging the cash flows. Similarly, the equity tranche may be sold to investors or held by the collateral manager. The key point is that there should be no moral hazard problems as associated with balance sheet CDOs.

It is typically very costly to fully fund the SCDO. Rather, the convention is to only partially fund the portfolio where the remainder is retained or serves as the reference for an unfunded credit risk transfer. Intuitively, securities are issued for less than the face value of the collateral pool. Hence, only part of the pool is backed by real assets in case of default. The so-called **super-senior tranche** is placed at the top of the capital structure even though there is no capital backing the security. The super-senior tranche will still be considered AAA because of the extensive subordination (i.e., creating tranches of differing priority levels).

## Regulatory Capital Considerations

The details of regulatory capital computation, as you can imagine, can be quite complex. Our goal here is to develop a basic understanding of the issues related to SCDOs. First, let us consider fully funded SCDOs. The regulatory capital charge is equal to 100% of the residual tranche retained by the originator plus a risk-adjusted charge for the actual swap (CDS) based on the collateral. For example, if the CDS is backed by Treasuries, the capital charge is 0%. According to Basel (at the time the original reading was written), a 20% capital charge will be levied if the underlying collateral debt is issued by an Organization for Economic Cooperation and Development (OECD) bank. As you will see in the Basel Reference Readings in Book 3, the risk weighting is relative to the base-case of 8% capital.

**Example: Determining regulatory capital**

Southern Tier Bank has synthetically securitized a $100 million loan portfolio. The bank will retain 2% of the issue. **Calculate** the regulatory capital if the deal is collateralized with (1) Treasuries and (2) OECD debt.

**Answer:**

1. Since the bank retains the equity tranche at full 100% weighting, the capital requirement will be 2% × $100 million = $2 million. There is no additional charge for the collateral since U.S. Treasuries carry a risk weighting of 0% (0% × 8% × $100 million).

2. The same $2 million capital charge for the equity tranche applies. Now, we apply the 20% risk weighting on the OECD debt (20% × 8% × $100 million = $1.6 million). Hence, the total capital charge is 3.6 million ($2 million + $1.6 million).

Note that under this structure, the SPE is still the issuer of the securities but the OECD bank is in the middle between the SPE and the originator. The bank serves as a fronting credit protection provider. From the investment management perspective, the safer the collateral pool, the less yield available to provide to the ultimate purchasers of the securities. Suppose the collateral manager decides to hold AAA rated bonds rather than Treasuries in the collateral pool. From an investor standpoint, a higher return is attainable due to the higher yielding securities. On the other hand, investors may apply a discount to the assets held by the trustee due to market risk of the collateral. Therefore, the SPE may add a credit enhancement to provide more protection to the investors.

For partially funded structures, the same general concepts apply to regulatory capital computation. The new wrinkle is to account for the charge that must be calculated against the unfunded super-senior tranche. Ultimately, the capital charge is based on the decision of the collateral manager to leave as is or hedge via a CDS. If the super-senior is left unhedged, then the standard risk weights discussed previously would apply.

## Benefits of Synthetic CDOs

There are several benefits of synthetic CDOs relative to traditional balance sheet CDOs.

1. Synthetics avoid the associated legal issues of loan sales (particularly if multiple taxing authorities are involved) and covenants. Syndicated loans may have resale restrictions that reduce the economic incentive to securitize.

2. The SCDO structure provides tremendous flexibility to the structuring agent relative to balance sheet CDOs. The ISDA documentation is much simpler than loan documentation and transfers. Banks are able to create specific payoffs, deductibles, *n*th-to-default, and other features specific to their financing and risk management needs.

3. The advances in CDS documentation have helped facilitate the rapid growth in the market. Some proponents feel (and are pushing for) the disappearance of traditional CDOs altogether.

4. The synthetic structure allows banks and investors to isolate credit risk from interest rate risk, political risk, and other risk factors.

5. The super-senior structure allows financing at rates even better than AAA rates.

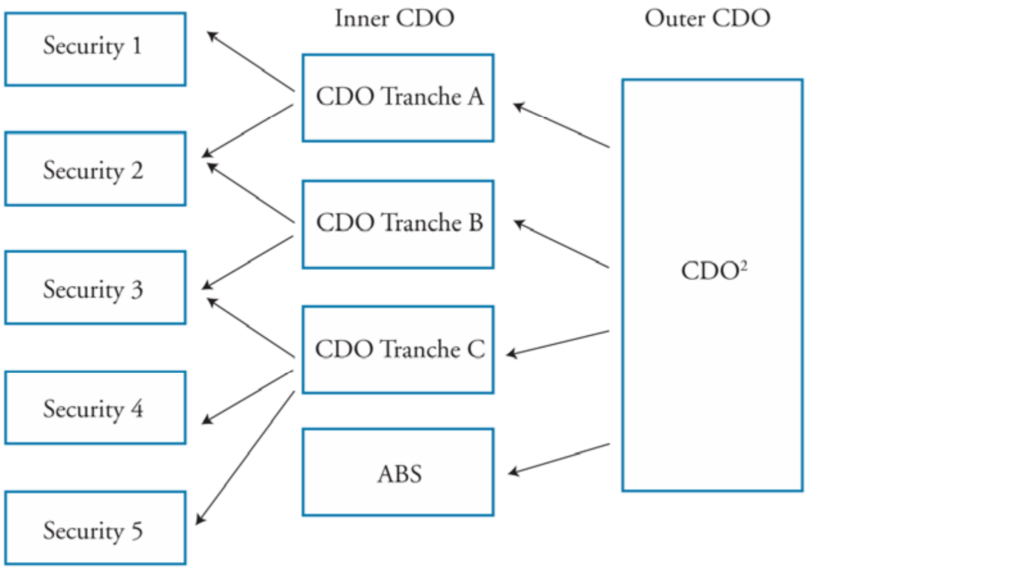
## Second Generation Synthetic CDO Structures

The birth of **single-tranche synthetic CDOs** (STSCDO) fundamentally changed the synthetic CDO market. Now the investor delineates the terms and exposures they seek. The desired exposure is typically mezzanine debt referencing a basket of single-name CDSs. Unlike the previous synthetic structures, the originator will issue only a single class (i.e., claim) against the synthetic pool. This has a number of implications. First, the structuring agent will retain the exposure from the pool remainder either actively hedging the credit risk or placing the issue at a later date. By initially issuing a single class, the transactional issues are minimized and the speed to bring the issue to the investor increases dramatically.

A **synthetic resecuritization** is simply a CDO of other CDO tranches issued as a new security. This is a general term as the CDO tranches may originate from ABS, residential MBS, commercial MBS, and other debt instruments.

The **CDO squared** ($CDO^2$) is a special case of resecuritization where the reconstituted tranches are CDOs. In effect, the CDO squared structure is a CDO of CDOs. The process of constructing the $CDO^2$ is the same as we saw for simpler structures except the underlying collateral is different. In addition, the $CDO^2$ structure is also a repository for segments of other arbitrage CDOs, particularly equity tranches, which were not placed with investors. Hence, unsold and unattractive tranches can now be packaged and sold to investors after a resecuritization.

**Figure 4: CDO Squared**




The **single-tranche $CDO^2$** is a related structure where a portfolio of STSCDOs is assembled. From this pool, a single (typically) mezzanine tranche is sold. There is great flexibility in determining the size and attachment points and, hence, the credit rating, of the tranche.

The **master CDO structure**, or repackaging, is a CDO backed by a portfolio of ABSs and a portfolio of STSCDOs. The innovation came about to counter the shrinking funding gap and reduced returns to equity holders. To make the issue more attractive, extra yield can be earned by adding a basket of STSCDOs. This has actually led to an increase in demand for STSCDOs.

## Synthetic CDOs vs. Insurance

As mentioned in previous topics, credit derivatives are not insurance contracts. Investors may buy protection without owning the underlying, so a credit event is not necessarily related to any economic loss. In contrast, insurance payments serve to reimburse the loss on the insured. Furthermore, even if the buyer of protection owned the underlying, the contingent payoff on the reference may not coincide with the conditions to trigger an

insurance payout, further delineating the products. In a synthetic structure such as SCDO, the exposure is created via CDS sale. Therefore, in default the payment is made but is not true reimbursement, as the protection buyer need not, and probably does not, own the asset. As credit market innovation keeps advancing at its rapid pace, current regulation may not be able to easily distinguish between insurance and credit risk management.

# Key Concepts

## LO 36.1

CDOs are asset-backed securities that promise investor principal and interest based on the collateral pool. The CDO seller may be motivated by credit or balance sheet management (balance sheet CDOs) or profit from financially engineering the cash flows (arbitrage CDOs). Buyers of CDOs are seeking new and enhanced security returns.

## LO 36.2

The collateral pool may consist of bonds (CBO), loans (CLO), or both.

## LO 36.3

Balance sheet CDOs typically consist of loans because those are the assets on a bank's balance sheet. Arbitrage CDOs must buy the collateral in the open market, so the underlying pool is likely bonds.

Balance sheet CDOs benefit the originator through credit risk management, maintaining debt capacity, reducing the size of the balance sheet, lowering agency costs, and reducing regulatory capital. Arbitrage CDOs are motivated by new and creative ways to entice investors from financial engineering cash flows. The managers seek to maximize profit via the funding gap between the collateral pool and the weighted average cash flows due to investors.

## LO 36.4

Market value CDOs use the proceeds from asset sales to satisfy the promised cash flows to investors. On the other hand, cash flow CDOs use the scheduled principal and interest of the underlying collateral to repay investor claims.

## LO 36.5

Static CDOs essentially describe balance sheet CDOs because the collateral manager's primary role is to select the assets for the collateral pool. Active management is prohibited. On the other hand, arbitrage CDOs are considered managed. The degree of active management can range from light (discretionary preemptive trades) to full-blown active management.

## Concept Checkers

1. Which of the following is not a potential benefit from a balance sheet CDO transaction?
   A. Decrease regulatory capital.
   B. Increase transparency of assets.
   C. Raise WACC from decreasing agency costs.
   D. Reduce the size of the balance sheet.

2. Which of the following statements is most correct concerning market value CDOs? Market value CDOs:
   A. represent a fast growing segment of the CDO market.
   B. have higher transparency than cash flow CDOs.
   C. periodically liquidate assets to fulfill investor obligations.
   D. are less tax efficient than cash flow CDOs.

3. Which of the following statements is most accurate concerning static and active CDOs?
   A. Active CDO managers have fewer reinvestment decisions than static CDOs.
   B. Active CDOs will have shorter ramp-up periods than static CDOs.
   C. Static CDOs will employ collateral managers.
   D. The development of static CDOs are likely driven by credit management reasons.

4. Which of the following is true regarding balance sheet and arbitrage CDOs?
   A. Arbitrage CDOs are motivated by financial engineering of the cash flows to maximize profits.
   B. Balance sheet CDOs are less likely to retain the equity tranche.
   C. The trustee has a more important role in the arbitrage CDOs.
   D. Arbitrage CDOs will contain a greater proportion of loans in the collateral pool.

5. Which of the following statements is true about the cash collateral account (CCA)? The CCA is:
   A. a credit enhancement to protect the originator from cash shortfalls.
   B. a credit enhancement to protect the investors from cash shortfalls.
   C. excess spread that accrues to the residual equity tranche.
   D. excess spread that accrues to the structuring agent.

## Concept Checker Answers

1. **C** Reducing agency costs associated with poor project selection will decrease the WACC, thereby raising firm value.

2. **C** Market value CDOs are rapidly disappearing. Transparency should be the same between market value and cash CDOs. Tax efficiency is primarily a function of the investor and not relevant to this topic.

3. **D** Balance sheet CDOs essentially describe static CDOs. A primary motivation for balance sheet CDOs is credit risk or balance sheet management. Active CDOs will have more reinvestment decisions and longer ramp-up periods to acquire assets. Active CDOs will need dedicated collateral managers as opposed to static CDOs.

4. **A** Balance sheet CDOs are more likely to retain the equity tranche to mitigate the adverse selection problem for skimming the higher quality assets from the collateral pool. The trustee role is the same for both balance sheet and arbitrage CDOs. Balance sheet CDOs are more likely to contain more loans because it likely originated them.

5. **B** CCA is excess spread, a type of credit enhancement that accumulates for the benefit of investors in case of cash flow shortfalls.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

# Understanding the Securitization of Subprime Mortgage Credit

Topic 37

## Exam Focus

This topic describes many important aspects of the subprime markets. Seven frictions between market participants are discussed involving mortgagors, originators, arrangers, rating agencies, asset managers, and investors. You should understand the information problem (moral hazard or adverse selection) for each friction. Characteristics of subprime mortgages are also discussed including loan terms, performance, and subordination. For the exam, be familiar with subprime mortgage securitization, the frictions in the subprime market, and the process of rating subprime securities.

## The Subprime Securitization Process

### LO 37.1: Explain the subprime mortgage credit securitization process in the United States.

The subprime securitization process in the United States involves several different parties beginning with the borrowing needs of the home buyer. The borrower (mortgagor) applies for a mortgage and, conditional on the due diligence of the lender, is extended a loan with the residence serving as collateral. Borrowers range in quality from prime (i.e., strong credit history) to Alt-A (i.e., borrowers with good credit but more aggressive underwriting standards) to subprime (i.e., borrowers with poor credit history). Lenders sell a significant portion of their loans to a third-party (special purpose vehicle) and receive cash in return. Prime loans that meet conforming standards are sold to government sponsored enterprises (GSEs). The remaining loans are increasingly being sold and taken off the originators' balance sheet. Approximately 75% of newly originated subprime mortgages were securitized in 2005 and 2006.

## Frictions in Subprime Mortgage Securitization

### LO 37.2: Identify and describe key frictions in subprime mortgage securitization, and assess the relative contribution of each factor to the subprime mortgage problems.

In general, when two parties do not have the same information (which is usually the case), a sub-optimal outcome results. The two broad classes of information problems we will discuss here are moral hazard and adverse selection. **Moral hazard** denotes the actions one party may take to the detriment of the other. A classic example is the shareholder-manager relationship where the managers may use their position for personal gain rather than for

the shareholders to whom they owe a fiduciary duty. On the other hand, **adverse selection** is when one party possesses important hidden information. For example, a person's driving ability is private knowledge and a potential buyer of auto insurance will have the incentive to represent themselves as good drivers even if they are not. Mechanisms are designed to minimize these information problems such as board oversight for the managers and examination of driving records for those seeking auto insurance.

There are seven frictions in the mortgage securitization process. Each friction is discussed as follows.

*Friction 1:* *Mortgagor and originator*. The typical subprime borrower is typically financially unsophisticated. As a result, the borrower may not select the best borrowing alternative for themselves. In fact, the borrower may not even be aware of the financing options available. On the other hand, the lender may steer the borrower to products that are not suitable.

*Friction 2:* *Originator and arranger*. The arranger (issuer) purchases the loans from the originators for the purpose of resale through securitized products. The arranger will perform due diligence but still operates at an information disadvantage to the originator. That is, the originator has superior knowledge about the borrower (adverse selection problem). In addition, the originator may falsify or stretch the bounds of the application resulting in larger than optimal lending (predatory lending or predatory borrowing as discussed in LO 37.8).

*Friction 3:* *Arranger and third-parties*. The arranger of the pool of mortgages will possess better information about the borrower than third parties including rating agencies, asset managers, and warehouse lenders. The adverse selection problem gives the arranger the opportunity to retain the higher quality mortgages and securitize the lower quality mortgages (i.e., lemons).

The warehouse lender temporarily holds and finances the underlying purchases. As a precaution, the warehouse will fund less than 100% of its estimated collateral value forcing the arranger to retain a equity position on its balance sheet.

The asset portfolio manager purchases the assets for the pool from the arranger. Once again, the arranger has superior information about the creditworthiness of the mortgage pool. To minimize the potential adverse selection problem, the asset manager must use adequate due diligence, use reputable arrangers, and force credit enhancements from the arranger.

Similarly, the rating agencies determine the amount of credit enhancement necessary to achieve the desired credit rating. Thus, the rating agency is dependent on the information provided by the arranger. Typically, the due diligence on the arranger and originator is rushed.

*Friction 4:* *Servicer and mortgagor*. The servicer's role is to manage the cash flows of the pool and follow up on delinquencies and foreclosures. A conflict of interest arises for delinquent loans. The homeowner in financial difficulty does not have the incentive to upkeep tax payments, insurance, or maintenance on the

property. Escrowed funds can minimize this problem but ultimately efficient foreclosure must comply with federal regulations.

*Friction 5:* *Servicer and third-parties*. The servicer faces a moral hazard problem because their (lack of) effort can impact the asset manager and credit rating agencies without directly affecting their own cash flow distribution. In delinquency, the servicer is responsible for the property taxes and insurance premiums. These funds are reimbursable upon foreclosure so there is a temptation to exaggerate the fees and expenses particularly with high recovery rates.

The servicer also has an incentive to keep the problem loan on its books by modifying loan terms rather than foreclose (investor preference). Since most of the costs are unrecoverable (escrow analysis, payment set up, etc.) the property needs to be active to generate any additional funds to the servicer.

It is apparent that the quality of the servicer can directly impact the cash flows of the pool which in turn affects the credit rating. Changes in credit ratings reflect poorly on the agency. Therefore, the credit rating agencies must use due diligence in analyzing the servicer as well as the underlying collateral.

*Friction 6:* *Asset manager and investor*. The investor relies on the asset manager's expertise to identify and analyze potential investments. It is difficult for the investor to comprehend the investment strategy and the investor will not be able to observe the effort of the management team (same moral hazard problem as shareholder-manager). Investment mandates and proper benchmarking can mitigate some of the distortion.

*Friction 7:* *Investor and credit rating agencies*. Rating agencies are compensated by the arranger and not the end user, the investor. To the extent that the rating agencies are beholden to the fee structure of the arranger, a conflict of interest arises. In addition, it is very difficult to judge the accuracy of their models particularly with complex products and rapid financial innovation.

Five of the above factors are direct contributors to the recent subprime crisis. First, the complexity of the product and naïve nature of the borrower led to inappropriate loans (friction 1). Second, managers sought the additional yield from structured mortgage products without fully assessing the associated risks (friction 6). Third, the problem became more expansive as underperforming managers made similar investments with less due diligence on the arranger and originator (friction 3). Fourth, as the asset managers reduced their oversight, it was natural that the arranger would follow suit (friction 2). This left the credit rating agencies as the last line of defense but they operated at a significant informational disadvantage. Finally, the assigned ratings were hopelessly misguided (friction 7).

## Characteristics of the Subprime Mortgage Market

**LO 37.3: Describe the characteristics of the subprime mortgage market, including the creditworthiness of the typical borrower and the features and performance of a subprime loan.**

Subprime borrowers have a history of either default or strong indicators of possible future default. Past incidents include 30- or 60-day delinquencies, judgments, foreclosures, repossessions, charge-offs, or bankruptcy filings. Low FICO scores (660 or below) or a high debt service ratio of 50% or more are likely indicators of future default.

The vast majority of subprime loans are adjustable rate mortgages. The loan offers a teaser rate for a short period of time, and then adjusts each year relative to a floating rate index (usually LIBOR). The 2- and 3-year teaser rates are called 2/28 and 3/27 hybrid arms denoting the fixed and floating terms, respectively (e.g., fixed term is 2 years, floating term is 28 years). Since the majority of the term of the mortgage is floating, the borrower is bearing the interest rate risk in contrast to a traditional fixed rate mortgage where the lender bears the interest rate risk.

The performance of subprime pools indicates defaults and foreclosures way above historical levels. As a point of reference, the authors of the assigned reading analyze a New Century pool originating in May 2006 and estimate a 23% cumulative default rate through August 2007.

Securitized pools incorporate structures to provide protection to investors from losses in the collateral including subordination, excess spread, shifting interest, performance triggers, and interest rate swaps.

**Subordination** involves creating tranches of differing priority levels. Losses are applied first to the most subordinated tranche, the equity tranche. The equity tranche is usually created from overcollateralization (i.e., assets in excess of face value). If the losses exceed the size of this tranche then losses will reach the next highest subordinated level called the mezzanine. Credit ratings on mezzanine debt typically vary from AA to B. In this fashion, the most senior tranche is protected by all the junior tranches and offers the lowest return.

Mortgages pools are typically constructed so that the weighted average coupon (less servicing, hedging, and other expenses) exceeds the weighted average payout. The difference is called the **excess spread** which is paid to equity tranche investors when available. Thus, the excess spread protects all tranches.

Under **shifting interest**, the senior investors receive all principal in the pool while the mezzanine investors receive only interest. The senior holders may receive the principal for a set period of time ("lockout period") or until a cutoff ratio is reached.

**Performance triggers** denote the release of overcollateralizion which is applied from the bottom of the capital structure up.

Since the first few years of the pool are fixed, the pool faces interest rate risk. As protection, **interest rate swaps** are used where the pool will pay a fixed rate and receive a floating rate.

## The Credit Ratings Process

### LO 37.4: Describe the credit ratings process with respect to subprime mortgage backed securities.

A credit rating is defined as an opinion on the creditworthiness of the specific bond issue. Note that the assigned rating is specific to the security and in no way a reflection on the originator. The ratings represent an unconditional view of the rating agency as they rate "**through-the-cycle**."

The rating process involves two steps: (1) estimation of loss distribution and (2) simulation of the cash flows. Once the estimates are obtained, the agency indicates the level of credit enhancement necessary to achieve the desired rating. If the projected rating is too low, the originator can provide additional enhancement to raise the rating.

### LO 37.5: Explain the implications of credit ratings on the emergence of subprime related mortgage backed securities.

Assigning credit ratings for securitized assets presents additional challenges. Credit ratings for subprime securities, and more generally asset-backed securities (ABS), differ from corporate ratings in several important ways. First, corporate bond ratings are based on the firm-specific characteristics of the issuer where as ABS is a claim on a portfolio. Hence, systematic risk and degree of correlation between assets is important in the latter but not the former. ABS represents claims on a static pool and cannot infuse additional capital or restructure as a corporation can. In addition, the forecasts for ABS incorporate future economic conditions since the cash flow stream is tied to the macro environment. Finally, while corporates and ABSs with the same rating may indicate similar default probabilities, the ABS will exhibit much wider variation in losses.

### LO 37.6: Describe the relationship between the credit ratings cycle and the housing cycle.

The goal of the rating system is to rate through-the-cycle, meaning that there should not be excessive upgrades (downgrades) if the housing market heats up (slows down). A problem may arise if the agency assigns, say, an AAA rating during a boom period. As the housing market slows down, the probability of default increases and the security has migrated to AA even though the agency has not made a public pronouncement. The problem is further exacerbated if new deals are based on the credit enhancements from the AAA rating in the boom period.

As economic conditions change, it is expected to see some upgrades or downgrades in mortgage-backed securities. However, the effect may amplify up and down markets. For example, in a downward trending market, additional enhancements are needed to maintain the highest ratings. This "crowds out" the credit available for lower rated borrowers increasing the required loan rate or raising qualification standards. The opposite is true for housing upturns freeing up credit for lower rated borrowers.

### Cash Flow Analysis of Excess Spread

In the ratings process it is necessary to simulate the cash flows of the structure to forecast the degree of excess spread used for credit enhancement. As you can imagine, the forecasts are complex and depend on several interrelated factors including credit enhancement, timing of losses, prepayment rates, interest rates, trigger events, weighted average loan rate decrease, prepayment penalties, pre-funding accounts, and hedging instruments. The more important factors are discussed as follows.

First, the credit enhancement identifies the amount of collateral that can be impaired before the tranche suffers an economic loss. The timing of losses is also important because as losses accumulate, less excess spread will be available. A more conservative approach would front-load the losses. Prepayments will directly impact the excess spread. Prepayments may be voluntary (refinance, sales) or involuntary (default) so the prepayment assumption directly impacts the cash flow analysis. Prepayments typically follow the CPR (conditional prepayment rate) convention. However, it is important to note that hybrids will have higher than predicted defaults on or about the reset date due to the sudden change in rates and financial condition of the subprime borrower. A more conservative view would accelerate prepayments reducing further interest collections. Finally, the path of interest rates introduces uncertainty into the projected cash flow stream. Interest rates determine the adjustments (i.e., cash inflows), and influence refinancing.

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## LO 37.7: Explain the implications of the subprime mortgage meltdown on portfolio management.

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Currently, the rating agencies collectively monitor approximately 10,000 mortgage pools. It would be impractical to monitor each pool on a monthly basis in detail. It is current practice to annually review each individual pool. An important performance measure used during this review is the **loss coverage ratio** (LCR), defined as: (current credit enhancement for tranche) / (estimated unrealized losses). An example of a credit enhancement is excess spread. If the LCR is breached (i.e., falls below what is acceptable), a full review is warranted.

## Predatory Lending and Borrowing

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## LO 37.8: Compare predatory lending and borrowing.

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**Predatory lending** results in the borrower becoming worse off after the loan than before. This may happen because the rates are deceptively high, the appraisals are inflated allowing the borrower to extract equity and then cannot refinance, and prepayment penalties are extreme, steering borrowers unnecessarily to subprime products and similar ruses. Predatory lending may also include outright fraudulent activity in addition to deception.

**Predatory borrowing** is misrepresentation in the mortgage application from the borrower side. The temptation is driven by increasing housing prices whereby the borrower feels that he cannot catch up with housing prices. Therefore, lying on the mortgage application allows the borrower to the buy the house with the expectation that continued appreciation will allow a favorable refinancing. The fraud may be perpetrated by the buyer alone or in concert with lawyers, broker, and appraisers.

## Key Concepts

### LO 37.1

The recent past has witnessed about 75% of subprime mortgages securitized.

### LO 37.2

Frictions involve the borrower, originator, arranger, asset manager, investor, and rating agency. The frictions are based on adverse selection and moral hazard problems.

Ultimately, the lack of due diligence on the asset manager and arranger led to even looser underwriting standards. The credit rating agencies issued ratings that lacked this key information.

### LO 37.3

Subprime mortgages are mainly hybrid arms (2/28 and 3/27) where the term denotes fixed and floating, respectively. Hence, the borrower retains the vast majority of the interest rate risk.

The capital structure of a pool places the safest securities on top (senior notes), junior securities in the middle (mezzanine) and riskiest on the bottom (equity).

Subordination, excess spread, and shifting interest provide protection for the senior tranches.

### LO 37.4

Credit ratings are determined by the amount of collateralization in the structure. If the projected cash flows are insufficient to warrant a desired rating, the originator can supply additional enhancement.

### LO 37.5

Credit ratings for ABSs are more complex than corporate ratings because of the underlying portfolio nature and correlation between assets, dependence on economic forecasts, and static nature of the collateral pool.

### LO 37.6

Credit ratings are designed to rate through-the-cycle so that there are not excessive upgrades (downgrades) during housing booms (busts). However, changing required enhancements amplify the impact on housing markets by reducing credit in down markets and increasing credit in up markets for the lowest rated borrowers.

## LO 37.7

Rating agencies collectively monitor approximately 10,000 mortgage pools. It's impractical to monitor each pool on a monthly basis in detail, so annual reviews are preferred.

## LO 37.8

Predatory lending is when the borrower's welfare is reduced after undertaking the loan. The key characteristic is that the borrower has entered into an agreement with unfavorable terms. Predatory borrowing is when the borrower knowingly misrepresents his financial condition to secure a loan that he otherwise would not qualify for.

## Concept Checkers

1. Which of the following is not a friction in the subprime securitization market?
   A. Investor and rating agency.
   B. Servicer and mortgagor.
   C. Mortgagor and arranger.
   D. Asset manager and investor.

2. Which of the following frictions represents an adverse selection problem?
   A. Investor and mortgagor.
   B. Originator and arranger.
   C. Servicer and rating agency.
   D. Servicer and mortgagor.

3. Which of the following statements about subprime mortgages is true? Subprime mortgages:
   A. are typically fixed rate obligations.
   B. often use the 2/28 or 3/27 hybrid structure.
   C. force the lender to bear most of the interest rate risk.
   D. are simpler to analyze than corporate bonds.

4. Which of the following is true about predatory lending and predatory borrowing?
   A. Both underprovide credit.
   B. Both overprovide credit.
   C. Predatory lending underprovides credit and predatory borrowing overprovides credit.
   D. Predatory lending overprovides credit and predatory borrowing underprovides credit.

5. Which of the following subprime characteristics provide direct protection for senior tranches?
   A. Subordination, excess spread, and shifting interest.
   B. Subordination, prepayments, and shifting interest.
   C. Overcollateralization, excess spread, and timing of losses.
   D. Overcollateralization, excess spread, and prepayments.

## Concept Checker Answers

1. **C** The mortgagor and arranger have no direct contact so there is no friction.

2. **B** The originator has better information about the quality of the borrowers so the arranger is subject to an adverse selection problem. That is, if the originator keeps the high quality mortgages, the arranger will receive lemons.

3. **B** Most subprimes are 2/28 or 3/27 structures where the fixed component is for two or three years. Hence, the remainder of the term (27 or 28 years) is variable and bears the majority of the interest rate risk.

4. **B** Predatory borrowing is when the borrower misrepresents themselves to obtain credit they otherwise would be denied. Predatory lending is providing credit that is welfare decreasing and should not be provided.

5. **A** Subordination, excess spread, and shifting interest provide protection for senior tranches. Overcollateralization also provides protection for senior tranches. Timing of losses impacts excess spreads. Prepayments can accelerate or decelerate the cash flows to senior tranches.

# Self-Test: Credit Risk Measurement and Management

**10 Questions: 30 Minutes**

1. The Merton model and the Moody's KMV model use different approaches to determine the probability of default. Which of the following is consistent with Moody's KMV model?
   A. The distance to default is 1.96, so there is a 2.5% probability of default.
   B. The distance to default is 1.96, so there is a 5.0% probability of default.
   C. The historical frequency of default for corporate bonds has been 6%. Updating this with Altman's Z-score analysis would provide a probability of default that is somewhat different than 6%.
   D. The distance to default is 1.96 and, historically, 1.2% of firms with this characterization have defaulted, so there is a 1.2% probability of default.

2. A firm is experiencing financial difficulties. Using a contingent claims approach, which of the following best describes the valuation of their senior and subordinated debt?
   A. Both the senior debt and subordinated debt have positive exposures to debt maturity, firm volatility, and interest rates (i.e., the debt value increases as these factors increase).
   B. The senior debt has negative exposures to debt maturity, firm volatility, and interest rates (i.e., the senior debt value decreases as these factors increase). The subordinated debt has positive exposures to debt maturity, firm volatility, and interest rates (i.e., the subordinated debt value increases as these factors increase).
   C. The senior debt has positive exposures to debt maturity, firm volatility, and interest rates (i.e., the senior debt value increases as these factors increase). The subordinated debt has negative exposures to debt maturity, firm volatility, and interest rates (i.e., the subordinated debt value decreases as these factors increase).
   D. Both the senior debt and subordinated debt have negative exposures to debt maturity, firm volatility, and interest rates (i.e., the debt value decreases as these factors increase).

3. A portfolio consists of two bonds, Bonds A and B. The credit VaR for the portfolio is defined as the maximum loss due to defaults at a confidence level of 98% over a one-year horizon. The probability of joint default of the two bonds is 1.32%, and the default correlation is 35%. The bond value, default probability, and recovery rate are USD 1.2 million, 4%, and 60%, respectively for Bond A, and USD $800,000, 5%, and 35%, respectively for Bond B. What is the expected credit loss for the portfolio?
   A. $45,200.
   B. $15,820.
   C. $42,800.
   D. $26,400.

4. Given the following parameters for a firm, what is the value of the firm's equity?
   - Asset value of $180.
   - Risk-free rate of 5%.
   - $100 par value debt with a 7% coupon, maturing in one year.
   - A European put option worth $1.50 on the firm's assets with a strike price equal to the face value of debt.

   A. $74.00.
   B. $74.52.
   C. $79.20.
   D. $79.72.

5. Suppose a portfolio has a value of $1,000,000 with 50 independent credit positions. Each of the credits has a default probability of 2% and a recovery rate of 0%. The credit portfolio has a default correlation equal to 0. The number of defaults is binomially distributed and the 95th percentile of the number of defaults is 3. What is the credit value at risk at the 95% confidence level for this credit portfolio?
   A. $20,000.
   B. $40,000.
   C. $60,000.
   D. $980,000.

6. Continuously increasing default probability (while holding default correlation constant) will most likely have what effect on the credit VaR of mezzanine and equity tranches?

| | Equity VaR | Mezzanine VaR |
|---|---|---|
| A. | Increase | Increase then decrease |
| B. | Increase | Decrease then increase |
| C. | Decrease | Increase then decrease |
| D. | Decrease | Decrease then increase |

7. Which of the following statements regarding counterparty risk and lending risk is correct?
   A. For an interest-rate swap, counterparty risk exists because default may occur at the end of the contract term.
   B. With counterparty risk, there is uncertainty as to which counterparty will have a negative mark-to-market value.
   C. Lending risk involves bilateral risks.
   D. With lending risk, the principal amount at risk is known with absolute certainty at the outset.

8. Teresa Harrison, a junior portfolio manager, is considering the purchase of super senior tranches for her client portfolios. The typical client is fairly conservative and concerned more with downside risk than upside potential. Harrison based her recommendation on the following observations:
   - Senior tranches have large attachment points and hence a low probability of credit losses.
   - Mezzanine tranches represent the first loss piece of the capital structure.
   - Synthetic CDOs have standardized tranche widths similar to index tranches.

   How many of these observations support Harrison's view of tranches?
   A. 0.
   B. 1.
   C. 2.
   D. 3.

9. A collateralized mortgage obligation (CMO) has the characteristics below. Which of the following are most accurate regarding its credit enhancement?

| | |
|---|---|
| Return on assets | 8.75% |
| Senior tranche | \$400,000,000 |
| Subordinated tranche A | \$120,000,000 |
| Subordinated tranche B | \$50,000,000 |
| Value of collateral | \$600,000,000 |
| Interest paid on liabilities of SPE | 7.50% |
| Fees and expenses | 0.60% |

   I. There is overcollateralization.
   II. The investors gain credit enhancement through the excess spread.

   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

10. Which of the following characteristics is most likely associated with a collateralized debt obligation (CDO) issued by a bank?
   A. The underlying assets are bonds.
   B. The CDO is a managed CDO.
   C. The CDO is a balance sheet CDO.
   D. The residual interest is sold off to investors.

# Self-Test Answers: Credit Risk Measurement and Management

1. **D** Moody's KMV model evaluates the historical frequency of default for firms with similar distances to default and uses this as the probability of default.

   (See Topic 20)

2. **B** If a firm is in financial distress, the subordinated debt behaves more like equity and a call option. It will increase in value as time to maturity increases, volatility increases, and interest rates increase. The senior debt will have negative exposures to these factors.

   If the firm is not in distress, both the senior debt and subordinated debt have negative exposures to these factors because the subordinated debt behaves more like senior debt than equity. In this case, choice D would be correct.

   (See Topic 21)

3. **A** The joint expected credit loss is the sum of the two individual expected credit losses.

   EL = PD × exposure × LGD

   $EL_{Bond\ A}$ = \$1,200,000 × 0.04 × 0.40 = \$19,200

   $EL_{Bond\ B}$ = \$800,000 × 0.05 × 0.65 = \$26,000

   Total EL = \$45,200

   Note that expected credit loss does not depend on the correlation between the bonds.

   (See Topic 22)

4. **D** The firm's equity can be calculated as $E_t = A_t - D_t$. We can value $D_t$ using the Merton model:

   $D_t = De^{-r\tau}$ – (European put value with strike at D) = \$107 × $e^{-0.05\times1}$ – \$1.50 = \$100.28

   We can then calculate $E_t$:

   $E_t = A_t - D_t$ = \$180 – \$100.28 = \$79.72.

   (See Topic 22)

5. **B** The loss given default is \$60,000 [3 × (\$1,000,000 / 50)]. The expected loss is equal to the portfolio value times $\pi$ and is \$20,000 (0.02 × \$1,000,000). The credit VaR is defined as the quantile of the credit loss less the expected loss of the portfolio. At the 95% confidence level, the credit VaR is equal to \$40,000 (\$60,000 minus the expected loss of \$20,000).

   (See Topic 24)

6. **C** Increasing the probability of default decreases equity VaR as defaults are more likely, and the equity tranche will suffer writedowns. However, the writedowns are bounded by the thin level of subordination so the variation in losses becomes smaller. Mezzanine tranches behave more like senior bonds at low default levels (increasing VaR) but more like the equity tranche at higher default levels (decreasing VaR).

   (See Topic 25)

7. **B** With counterparty risk, there is uncertainty regarding which counterparty will have a negative MtM value. For an interest-rate swap, there is no counterparty risk at the end of the contract term because all payments required by the contract would have been made by then. With lending risk, only one party (unilateral) takes on risk. In addition, the principal amount at risk is known only with reasonable certainty at the outset because changes in interest rates, for example, will lead to some uncertainty.

   (See Topic 26)

8. **B** Only recommendation 1 is correct. Senior tranches have a low probability of default because their attachment points are much higher in the capital structure. Equity tranches represent the first loss position. Index tranches, not synthetic CDOs, have standardized tranche widths.

   (See Topic 30)

9. **C** The total value of the tranches is: \$400 + \$120 + \$50 = \$570 million. The value of the collateral is \$600 million, so the CMO is overcollateralized by \$30 million.

   The net excess spread is 8.75% – 7.50% – 0.60% = 0.65%, so there is positive excess spread. This provides credit enhancement for the CMO investors.

   (See Topic 35)

10. **C** With a balance sheet CDO, a bank takes assets off its balance sheet and places them in a CDO.

    (See Topic 36)

# Formulas

## Credit Risk Measurement and Management

### Topic 18

expected loss: PD × LGD × EAD

### Topic 20

Merton model: payment to debtholders = $D_M - \max(D_M - V_M, 0)$

payment to stockholders = $\max(V_M - D_M, 0)$

distance to default: $DD = \dfrac{\text{expected asset value} - \text{default threshold}}{\sigma_{\text{expected asset value}}}$

distance to default (lognormal distribution):

$$DD = \frac{\log(V) - \log(\text{default threshold}) + \left[E(ROA) - \dfrac{\sigma_v^2}{2}\right] \times \text{maturity}}{\sigma_v \times \sqrt{\text{maturity}}}$$

where:
E(ROA) = expected return on assets
V = value of the firm assets
$\sigma_v$ = standard deviation of firm assets

### Topic 21

$$\text{credit spread} = -\left[\frac{1}{(T-t)}\right] \times \ln\left(\frac{D}{F}\right) - R_F$$

where:
(T – t) = remaining maturity
D = current value of debt
F = face value of debt
$R_F$ = risk-free rate

vulnerable option = [(1 – PD) × c] + (PD × RR × c)

where:
c = value of the option without default
PD = probability of default
RR = recovery rate

## Topic 22

recovery rate: $RR = \dfrac{\text{recovery}}{\text{exposure}} = 1 - \dfrac{\text{LGD}}{\text{exposure}}$

expected loss: EL = PD × (1 – RR) × exposure = PD × LGD

$$E[\text{loss} \mid \text{default}] = \text{LGD} = \frac{\text{EL}}{P[\text{default}]} = \frac{\text{EL}}{\text{PD}}$$

asset return: $a_T = \beta m + \sqrt{1-\beta^2}\,\varepsilon$

## Topic 23

cumulative PD: $1 - e^{-\lambda t}$

default probability: $\lambda_T^* \approx \dfrac{z_T}{1-RR}$

## Topic 24

correlation with default probabilities: $\rho_{12} = \dfrac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$

## Topic 29

$$\text{netting factor} = \frac{\sqrt{n + n(n-1)\bar{\rho}}}{n}$$

where:
$n$ = number of exposures
$\bar{\rho}$ = average correlation

## Topic 30

risk-neutral default probability = liquidity premium + default risk premium + real-world default probability

cumulative default probability: $F(u) = 1 - \exp\left[-\frac{\text{spread}}{1 - \text{recovery}} \times u\right]$

marginal probability of default:

$$q\left(t_{i-1}, t_i\right) \approx \exp\left[-\frac{\text{spread}_{t_{i-1}}}{1 - \text{recovery}} \times t_{i-1}\right] - \exp\left[-\frac{\text{spread}_{t_i}}{1 - \text{recovery}} \times t_i\right]$$

$$\text{number of defaults} = n\left(\frac{X\%}{1 - \text{recovery}}\right)$$

## Topic 31

$$\text{CVA} \approx \text{LGD} \times \sum_{i=1}^{m} d\left(t_i\right) \times \text{EE}\left(t_i\right) \times \text{PD}\left(t_{i-1}, t_i\right)$$

where:
LGD = loss given default or how much of the exposure one expects to lose in the event of a counterparty default; equal to 1 minus the recovery rate (1 – RR)
EE = expected exposure for future dates
PD = marginal default probability
d(t) = discount factors or the risk-free rate component of the CVA at time *t*; future losses are discounted back to the present with these terms

CVA as a running spread:

$$\frac{\text{CVA}(t, T)}{\text{CDS}_{\text{premium}}(t, T)} = X^{\text{CDS}} \times \text{EPE}$$

where:
$\text{CDS}_{\text{premium}}(t, T)$ = unit premium value of a credit default swap
$X^{\text{CDS}}$ = CDS premium at maturity date *T*; this amount can be thought of as a credit spread
EPE = expected positive exposure that is the average of the expected exposure over a preset time period, typically from the present to the maturity date of the transaction

# Using the Cumulative Z-Table

## Probability Example

Assume that the annual earnings per share (EPS) for a large sample of firms is normally distributed with a mean of $5.00 and a standard deviation of $1.50. What is the approximate probability of an observed EPS value falling between $3.00 and $7.25?

If EPS = x = $7.25, then z = $(x - \mu)/\sigma$ = ($7.25 – $5.00)/$1.50 = +1.50

If EPS = x = $3.00, then z = $(x - \mu)/\sigma$ = ($3.00 – $5.00)/$1.50 = –1.33

*For z-value of 1.50:* Use the row headed 1.5 and the column headed 0 to find the value 0.9332. This represents the area under the curve to the left of the critical value 1.50.

*For z-value of –1.33:* Use the row headed 1.3 and the column headed 3 to find the value 0.9082. This represents the area under the curve to the left of the critical value +1.33. The area to the left of –1.33 is 1 – 0.9082 = 0.0918.

The area between these critical values is 0.9332 – 0.0918 = 0.8414, or 84.14%.

## Hypothesis Testing – One-Tailed Test Example

A sample of a stock's returns on 36 non-consecutive days results in a mean return of 2.0%. Assume the population standard deviation is 20.0%. Can we say with 95% confidence that the mean return is greater than 0%?

$H_0$: $\mu \leq 0.0\%$, $H_A$: $\mu > 0.0\%$. The test statistic = *z*-statistic = $\frac{\overline{x} - \mu_0}{\sigma / \sqrt{n}}$
= (2.0 – 0.0) / (20.0 / 6) = 0.60.

The significance level = 1.0 – 0.95 = 0.05, or 5%.

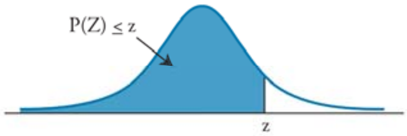
Since this is a one-tailed test with an alpha of 0.05, we need to find the value 0.95 in the cumulative *z*-table. The closest value is 0.9505, with a corresponding critical *z*-value of 1.65. Since the test statistic is less than the critical value, we fail to reject $H_0$.

## Hypothesis Testing – Two-Tailed Test Example

Using the same assumptions as before, suppose that the analyst now wants to determine if he can say with 99% confidence that the stock's return is not equal to 0.0%.

$H_0$: $\mu = 0.0\%$, $H_A$: $\mu \neq 0.0\%$. The test statistic (*z*-value) = (2.0 – 0.0) / (20.0 / 6) = 0.60.
The significance level = 1.0 – 0.99 = 0.01, or 1%.

Since this is a two-tailed test with an alpha of 0.01, there is a 0.005 rejection region in both tails. Thus, we need to find the value 0.995 (1.0 – 0.005) in the table. The closest value is 0.9951, which corresponds to a critical *z*-value of 2.58. Since the test statistic is less than the critical value, we fail to reject $H_0$ and conclude that the stock's return equals 0.0%.



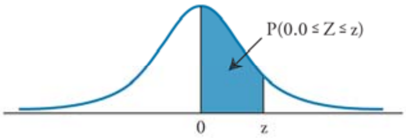

# CUMULATIVE Z-TABLE

$P(Z \leq z) = N(z)$ for $z \geq 0$

$P(Z \leq -z) = 1 - N(z)$

| z | 0 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.5000 | 0.5040 | 0.5080 | 0.5120 | 0.5160 | 0.5199 | 0.5239 | 0.5279 | 0.5319 | 0.5359 |
| 0.1 | 0.5398 | 0.5438 | 0.5478 | 0.5517 | 0.5557 | 0.5596 | 0.5636 | 0.5675 | 0.5714 | 0.5753 |
| 0.2 | 0.5793 | 0.5832 | 0.5871 | 0.5910 | 0.5948 | 0.5987 | 0.6026 | 0.6064 | 0.6103 | 0.6141 |
| 0.3 | 0.6179 | 0.6217 | 0.6255 | 0.6293 | 0.6331 | 0.6368 | 0.6406 | 0.6443 | 0.6480 | 0.6517 |
| 0.4 | 0.6554 | 0.6591 | 0.6628 | 0.6664 | 0.6700 | 0.6736 | 0.6772 | 0.6808 | 0.6844 | 0.6879 |
| | | | | | | | | | | |
| 0.5 | 0.6915 | 0.6950 | 0.6985 | 0.7019 | 0.7054 | 0.7088 | 0.7123 | 0.7157 | 0.7190 | 0.7224 |
| 0.6 | 0.7257 | 0.7291 | 0.7324 | 0.7357 | 0.7389 | 0.7422 | 0.7454 | 0.7486 | 0.7517 | 0.7549 |
| 0.7 | 0.7580 | 0.7611 | 0.7642 | 0.7673 | 0.7704 | 0.7734 | 0.7764 | 0.7794 | 0.7823 | 0.7852 |
| 0.8 | 0.7881 | 0.7910 | 0.7939 | 0.7967 | 0.7995 | 0.8023 | 0.8051 | 0.8078 | 0.8106 | 0.8133 |
| 0.9 | 0.8159 | 0.8186 | 0.8212 | 0.8238 | 0.8264 | 0.8289 | 0.8315 | 0.8340 | 0.8365 | 0.8389 |
| | | | | | | | | | | |
| 1 | 0.8413 | 0.8438 | 0.8461 | 0.8485 | 0.8508 | 0.8531 | 0.8554 | 0.8577 | 0.8599 | 0.8621 |
| 1.1 | 0.8643 | 0.8665 | 0.8686 | 0.8708 | 0.8729 | 0.8749 | 0.8770 | 0.8790 | 0.8810 | 0.8830 |
| 1.2 | 0.8849 | 0.8869 | 0.8888 | 0.8907 | 0.8925 | 0.8944 | 0.8962 | 0.8980 | 0.8997 | 0.9015 |
| 1.3 | 0.9032 | 0.9049 | 0.9066 | 0.9082 | 0.9099 | 0.9115 | 0.9131 | 0.9147 | 0.9162 | 0.9177 |
| 1.4 | 0.9192 | 0.9207 | 0.9222 | 0.9236 | 0.9251 | 0.9265 | 0.9279 | 0.9292 | 0.9306 | 0.9319 |
| | | | | | | | | | | |
| 1.5 | 0.9332 | 0.9345 | 0.9357 | 0.937 | 0.9382 | 0.9394 | 0.9406 | 0.9418 | 0.9429 | 0.9441 |
| 1.6 | 0.9452 | 0.9463 | 0.9474 | 0.9484 | 0.9495 | 0.9505 | 0.9515 | 0.9525 | 0.9535 | 0.9545 |
| 1.7 | 0.9554 | 0.9564 | 0.9573 | 0.9582 | 0.9591 | 0.9599 | 0.9608 | 0.9616 | 0.9625 | 0.9633 |
| 1.8 | 0.9641 | 0.9649 | 0.9656 | 0.9664 | 0.9671 | 0.9678 | 0.9686 | 0.9693 | 0.9699 | 0.9706 |
| 1.9 | 0.9713 | 0.9719 | 0.9726 | 0.9732 | 0.9738 | 0.9744 | 0.9750 | 0.9756 | 0.9761 | 0.9767 |
| | | | | | | | | | | |
| 2 | 0.9772 | 0.9778 | 0.9783 | 0.9788 | 0.9793 | 0.9798 | 0.9803 | 0.9808 | 0.9812 | 0.9817 |
| 2.1 | 0.9821 | 0.9826 | 0.983 | 0.9834 | 0.9838 | 0.9842 | 0.9846 | 0.985 | 0.9854 | 0.9857 |
| 2.2 | 0.9861 | 0.9864 | 0.9868 | 0.9871 | 0.9875 | 0.9878 | 0.9881 | 0.9884 | 0.9887 | 0.989 |
| 2.3 | 0.9893 | 0.9896 | 0.9898 | 0.9901 | 0.9904 | 0.9906 | 0.9909 | 0.9911 | 0.9913 | 0.9916 |
| 2.4 | 0.9918 | 0.9920 | 0.9922 | 0.9925 | 0.9927 | 0.9929 | 0.9931 | 0.9932 | 0.9934 | 0.9936 |
| | | | | | | | | | | |
| 2.5 | 0.9938 | 0.994 | 0.9941 | 0.9943 | 0.9945 | 0.9946 | 0.9948 | 0.9949 | 0.9951 | 0.9952 |
| 2.6 | 0.9953 | 0.9955 | 0.9956 | 0.9957 | 0.9959 | 0.9960 | 0.9961 | 0.9962 | 0.9963 | 0.9964 |
| 2.7 | 0.9965 | 0.9966 | 0.9967 | 0.9968 | 0.9969 | 0.9970 | 0.9971 | 0.9972 | 0.9973 | 0.9974 |
| 2.8 | 0.9974 | 0.9975 | 0.9976 | 0.9977 | 0.9977 | 0.9978 | 0.9979 | 0.9979 | 0.9980 | 0.9981 |
| 2.9 | 0.9981 | 0.9982 | 0.9982 | 0.9983 | 0.9984 | 0.9984 | 0.9985 | 0.9985 | 0.9986 | 0.9986 |
| | | | | | | | | | | |
| 3 | 0.9987 | 0.9987 | 0.9987 | 0.9988 | 0.9988 | 0.9989 | 0.9989 | 0.9989 | 0.9990 | 0.9990 |

# ALTERNATIVE *Z*-TABLE




$P(Z \leq z) = N(z)$ for $z \geq 0$

$P(Z \leq -z) = 1 - N(z)$

| z | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.0** | 0.0000 | 0.0040 | 0.0080 | 0.0120 | 0.0160 | 0.0199 | 0.0239 | 0.0279 | 0.0319 | 0.0359 |
| **0.1** | 0.0398 | 0.0438 | 0.0478 | 0.0517 | 0.0557 | 0.0596 | 0.0636 | 0.0675 | 0.0714 | 0.0753 |
| **0.2** | 0.0793 | 0.0832 | 0.0871 | 0.0910 | 0.0948 | 0.0987 | 0.1026 | 0.1064 | 0.1103 | 0.1141 |
| **0.3** | 0.1179 | 0.1217 | 0.1255 | 0.1293 | 0.1331 | 0.1368 | 0.1406 | 0.1443 | 0.1480 | 0.1517 |
| **0.4** | 0.1554 | 0.1591 | 0.1628 | 0.1664 | 0.1700 | 0.1736 | 0.1772 | 0.1808 | 0.1844 | 0.1879 |
| | | | | | | | | | | |
| **0.5** | 0.1915 | 0.1950 | 0.1985 | 0.2019 | 0.2054 | 0.2088 | 0.2123 | 0.2157 | 0.2190 | 0.2224 |
| **0.6** | 0.2257 | 0.2291 | 0.2324 | 0.2357 | 0.2389 | 0.2422 | 0.2454 | 0.2486 | 0.2517 | 0.2549 |
| **0.7** | 0.2580 | 0.2611 | 0.2642 | 0.2673 | 0.2704 | 0.2734 | 0.2764 | 0.2794 | 0.2823 | 0.2852 |
| **0.8** | 0.2881 | 0.2910 | 0.2939 | 0.2967 | 0.2995 | 0.3023 | 0.3051 | 0.3078 | 0.3106 | 0.3133 |
| **0.9** | 0.3159 | 0.3186 | 0.3212 | 0.3238 | 0.3264 | 0.3289 | 0.3315 | 0.3340 | 0.3356 | 0.3389 |
| | | | | | | | | | | |
| **1.0** | 0.3413 | 0.3438 | 0.3461 | 0.3485 | 0.3508 | 0.3531 | 0.3554 | 0.3577 | 0.3599 | 0.3621 |
| **1.1** | 0.3643 | 0.3665 | 0.3686 | 0.3708 | 0.3729 | 0.3749 | 0.3770 | 0.3790 | 0.3810 | 0.3830 |
| **1.2** | 0.3849 | 0.3869 | 0.3888 | 0.3907 | 0.3925 | 0.3944 | 0.3962 | 0.3980 | 0.3997 | 0.4015 |
| **1.3** | 0.4032 | 0.4049 | 0.4066 | 0.4082 | 0.4099 | 0.4115 | 0.4131 | 0.4147 | 0.4162 | 0.4177 |
| **1.4** | 0.4192 | 0.4207 | 0.4222 | 0.4236 | 0.4251 | 0.4265 | 0.4279 | 0.4292 | 0.4306 | 0.4319 |
| | | | | | | | | | | |
| **1.5** | 0.4332 | 0.4345 | 0.4357 | 0.4370 | 0.4382 | 0.4394 | 0.4406 | 0.4418 | 0.4429 | 0.4441 |
| **1.6** | 0.4452 | 0.4463 | 0.4474 | 0.4484 | 0.4495 | 0.4505 | 0.4515 | 0.4525 | 0.4535 | 0.4545 |
| **1.7** | 0.4554 | 0.4564 | 0.4573 | 0.4582 | 0.4591 | 0.4599 | 0.4608 | 0.4616 | 0.4625 | 0.4633 |
| **1.8** | 0.4641 | 0.4649 | 0.4656 | 0.4664 | 0.4671 | 0.4678 | 0.4686 | 0.4693 | 0.4699 | 0.4706 |
| **1.9** | 0.4713 | 0.4719 | 0.4726 | 0.4732 | 0.4738 | 0.4744 | 0.4750 | 0.4756 | 0.4761 | 0.4767 |
| | | | | | | | | | | |
| **2.0** | 0.4772 | 0.4778 | 0.4783 | 0.4788 | 0.4793 | 0.4798 | 0.4803 | 0.4808 | 0.4812 | 0.4817 |
| **2.1** | 0.4821 | 0.4826 | 0.4830 | 0.4834 | 0.4838 | 0.4842 | 0.4846 | 0.4850 | 0.4854 | 0.4857 |
| **2.2** | 0.4861 | 0.4864 | 0.4868 | 0.4871 | 0.4875 | 0.4878 | 0.4881 | 0.4884 | 0.4887 | 0.4890 |
| **2.3** | 0.4893 | 0.4896 | 0.4898 | 0.4901 | 0.4904 | 0.4906 | 0.4909 | 0.4911 | 0.4913 | 0.4916 |
| **2.4** | 0.4918 | 0.4920 | 0.4922 | 0.4925 | 0.4927 | 0.4929 | 0.4931 | 0.4932 | 0.4934 | 0.4936 |
| | | | | | | | | | | |
| **2.5** | 0.4939 | 0.4940 | 0.4941 | 0.4943 | 0.4945 | 0.4946 | 0.4948 | 0.4949 | 0.4951 | 0.4952 |
| **2.6** | 0.4953 | 0.4955 | 0.4956 | 0.4957 | 0.4959 | 0.4960 | 0.4961 | 0.4962 | 0.4963 | 0.4964 |
| **2.7** | 0.4965 | 0.4966 | 0.4967 | 0.4968 | 0.4969 | 0.4970 | 0.4971 | 0.4972 | 0.4973 | 0.4974 |
| **2.8** | 0.4974 | 0.4975 | 0.4976 | 0.4977 | 0.4977 | 0.4978 | 0.4979 | 0.4979 | 0.4980 | 0.4981 |
| **2.9** | 0.4981 | 0.4982 | 0.4982 | 0.4983 | 0.4984 | 0.4984 | 0.4985 | 0.4985 | 0.4986 | 0.4986 |
| | | | | | | | | | | |
| **3.0** | 0.4987 | 0.4987 | 0.4987 | 0.4988 | 0.4988 | 0.4989 | 0.4989 | 0.4989 | 0.4990 | 0.4990 |

# Index

# Notes